MACHINERY.

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FROM SMALL BEGINNINGS.

THERE is perhaps no better example of a steady growth from very small beginnings to an extensive plant than in the case of the Pratt & Whitney Co., of Hartford, Conn. Both Mr. Pratt and Mr. Whitney are thorough mechanics, Mr. Whitney having learned his trade of Mr. Blood, in Lawrence, Mass., in the old "Essex Machine Shop," which was afterward moved to Manchester, N. H., and is now known as the Manchester Locomotive Works. Mr. Pratt was apprenticed to Aldrich & Hayes, of Lowell, Mass., and the year 1854 found them both working at the Phœnix Iron Works of George S. Lincoln & Co., of Hartford, Mr. Pratt being the superintendent and Mr. Whitney a contractor in the shop, showing that the contract system, which is so prevalent in Hartford, was in use many years ago. In about 1860 Mr. Pratt and Mr. Whitney started a small shop on Potter street, in what was known as the old car shop, and made almost anything in the machine line which was wanted, one of their first products being a lot of "knock-off" motions for textile machinery. The force then consisted of four men, not including either Mr. Pratt or Mr. Whitney as they both retained their positions with Lincoln until 1864, but was looked after by Mr. Joseph E. Marvel, who is still with the firm. In 1861 they were burnt out and one of their men lost his life. Their next shop was in the old Wood Building, near the Post office, and was practically started by Mr. Monroe Stannard, who came to Hartford from New Britain, and was admitted to the firm in 1862, the firm then becoming Pratt. Whitney & Co., and in 1869 the Pratt & Whitney Co. was incorporated. The war breaking out soon after, created an immense demand for the Colt arms, and the new firm made many machines for them; milling machines, rifling machines, edgers (or vertical spindle millers for profiling or edging the forgings) and similar work.

AMOS WHITNEY.

Moving to their present location in 1862, they built quite a large shop for that time, and rented the greater portion of it to the Weed Sewing Machine Co. and to Robbins & Lawrence, who were making the "Sharps" rifle. Here they have remained and continue to add buildings to the plant until one wonders when they are going to stop, and yet the business keeps increasing so that everything is crowded most of the time.

Their milling machines, screw machines, planers and drilling machines furnish a large portion of their work, and they have probably made 7,000 Lincoln millers since they started. Of the screw machines in use to-day, probably the majority of them were built in these shops, and the special machines are too numerous to mention, but they form quite a large proportion of their work.

As the contract system is largely in use here, it is interesting to note its workings and results. The work is divided into departments according to the class of work required, and the heavy machine work, such as the planing and gear cutting for the whole shop is done in one department. Taking a milling machine as an example, and, with the exception of the planing, it is given by contract to the contractor who does that class of work. The drawings are furnished, the machine tools are furnished, and enough tools, such as jigs and fixtures, to do the job in good shape; then the contractor hires his men and goes to work.

There is very little piece work done, as the contractor does not find it profitable to sub-let his contracts (which is what piece work would amount to in this case), and the work is mostly day work. Some machines are even built day work for the firm, the contractors acting as the heads of smaller establishments.

When the contractor, who is the absolute head of his work, sees better means for doing it, such as the use of new and better jigs, he makes them at his own expense just as though he owned the shop, the advantage, if any, coming to him in the increased production of his men.

The apprentice system is also in vogue here and makes a very good training for boys who are capable of making good mechanics. When the applicant is under twenty-one he must serve a four years' term; if over that age, three years are required.

The boy is given all the variety of work he is capable of doing, and is allowed a chance in other departments to learn such branches as may not be used in his particular department, so he gets quite an insight in o th various kinds of work.

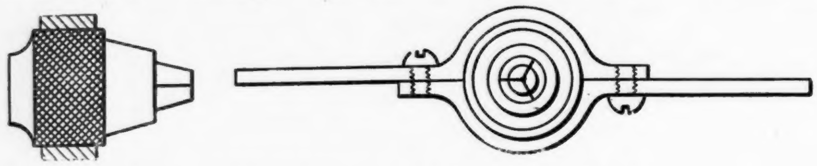
While not stipulated in the contract, if a boy shows especial aptitude he is frequently given a chance in the drawing-room after his apprenticeship is completed, and this gives one of the best trainings we know of for a large sh p.

* * *

For making a great number of very light castings from the same pattern, where it is desirable to save flasks, there may be used dissecting or hinged flasks, in which the sand may be rammed and which may be taken off, leaving the blocks of sand standing; the cope being held to the drag by a heavy iron plate which is laid on just before casting, and which has in it a hole through which to pour, this hole coming fair with the pouring hole in the cope.

A GOOD CHUCK WRENCH.

At the old shops of the Liberty Cycle Co., at Rockaway, N. J., they used a little wrench for an Almond chuck that was very handy for the work in hand. It was used for holding nipples to be tapped, and only a slight movement was needed to secure the necessary grip on the nipple. This gave the boy good control of



the chuck and increased its inherent usefulness in this particular work. The cut shows the construction very plainly. It seems needless to remark that this was used in the *tail stock*, or dead spindle, and not in the live, where its antics would hardly recomit for general use.

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THE DESIGN OF GEAR ARMS.

Henry Hess.

Every draftsman and engineer has at some time or other felt the need of a reliable formula to determine the size of a gear arm. On turning to some one of the many text and pocket books he has, if fortunate, found a rule that gave a good looking arm, only to be disappointed in his next application by finding the resultant arm altogether at variance with his knowledge of the fitness of things.

These rules having any value at all, base the dimensions of the arm upon the strength of the gear tooth, regarding the arm as a beam sustaining a load equal to the entire or some definite portion of the strength of the tooth. Unquestionably this method is rational—unfortunately also it stands or falls by the ability to correctly determine the load value of a gear tooth, and every engineer knows to his sorrow that all guides, from Reuleaux down, claiming ability to lead him to this goal, are themselves at fault. It was reserved to Mr. Wilfred Lewis to originate a method of determining the strength of gear teeth that at once removed the subject from the domain of empiricism to that of sound mechanical engineering. Briefly, his predecessors had all regarded a gear tooth as a beam of a thickness equal to half the circular pitch (in cut gears), and of a length equal to the full tooth height. Mr. Lewis objected that this was not true, as the thickness of the beam varied with the number of teeth in a gear, being greater for high numbered gears and less for low numbered gears than that assumed. The length of the beam he determined by constructing within the tooth outline the largest possible parabola having a base equal to the tooth base; the height of the parabola is the length of the effective tooth beam. The width of the beam is of course as usual the width of the tooth or gear face. Lewis' formula took the form, for the usual involute or cycloid tooth:

$$w = s\,c\,f\left(.124 - \frac{.888}{n}\right) = s\frac{\pi}{P}f\left(.124 - \frac{.888}{n}\right) \qquad (1)$$

w = working load in pounds.
s = stress in pounds.
c = circular pitch in inches.
P = diametral pitch.
f = face width in inches.
n = number of teeth in gear.

A gear arm is to be regarded as a beam rigidly supported at the center line of the gear and loaded at its extremity. The length of this beam is equal to the pitch radius of the gear. The load sustained is that capable of being impressed on the gear tooth as modified by the distributing influence of the gear rim and hub, which experience has shown to equally distribute this load among the total number of arms, whence

$$W = \frac{w}{N} \qquad (2)$$

W = load on gear arm.
w = load on gear tooth as determined by Willis' formula 1.
N = total number of gear arms.

For an arm of any section:

$$W = \frac{S\,Z}{L}$$

from which, by substituting the value of W from 2,

$$Z = \frac{w\,L}{N\,s} \qquad (3)$$

in which

Z = cross-section modulus.
L = length of arm in inches.

As length of arm L is always dependent upon the pitch of the gear teeth in the relation

$$L = \frac{n\,c}{2\pi} = \frac{n}{2P}$$

it follows that formula 3 can take the forms

$$Z = \frac{w\,n\,c}{N\,s\,2\pi} = \frac{w\,n}{N\,s\,2P}$$

Inserting the value of w from formula 1 gives:

$$Z = \frac{c^2 f(.124n - .888)}{2\pi N} = \frac{\pi f(.124n - .888)}{2P^2N} \qquad (4)$$

which will reduce to the simpler, closely approximate forms

$$\left.\begin{aligned} Z &= \frac{c^2 f(n-7)}{50\,N} \text{ for circular pitch} \quad (5)\\ Z &= \frac{.2f(n-7)}{P^2\,N} \text{ for diametral pitch} \quad (6)\end{aligned}\right\}\text{any arm section.}$$

A very good and usual gear-arm section is an ellipse in which the major axis is twice the minor; so that if

a = the minor axis of an elliptical gear arm section,
$2a$ = " major " " " " " " "

$$Z = \frac{\pi\,a\,(2a)^2}{32} = \frac{\pi a^3}{8}$$

Substituting these values in equations 4 and transposing gives:

$$\frac{\pi a^3}{8} = \frac{c^2 f(.124n - .888)}{2\pi N} = \frac{\pi f(.124n - .888)}{2P^2N}$$

which reduce to

$$a = \sqrt[3]{\frac{c^2 f\,4\,(.124n - .888)}{\pi^2 N}} = \sqrt[3]{\frac{4f(.124n - .888)}{P^2 N}}$$

which will in return reduce to the still simpler closely approimate

$$\left.\begin{aligned} a &= \sqrt[3]{\frac{c^2 f(n-7)}{20\,N}} \text{ for circular pitch}\\ a &= \sqrt[3]{\frac{f(n-7)}{2P^2N}} \text{ for diametral pitch}\end{aligned}\right\}\text{for elliptical arm section.}$$

It is to be understood that the dimensions found are for the base of the arm at the hub. The taper of the arm will vary to suit the eye of the designer; 1 in 16 for the major, and 1 in 32 for the minor diameter of an elliptical arm will look well. For long arms this taper is too great; for short arms too little; good judgment will determine the best taper.

These formulæ have been found to answer in practice for gears ranging from small lathe change gears to those used in the drivin trains of the heaviest plate bending rolls by one of the principal machine building firms of the country.

* * *

FLASKS.

In making flasks one of the principal objects should be to have them as small as possible up to the safety limit, by reason of lessening the amount of sand necessary; but they should enable the rammer to be used from two to three inches from the pattern; and if of wood there should be sufficient margin to keep the body of molten iron from burning them. Hence wooden flasks must be larger than those of iron, and the heavier the pour the more margin is required because there is a greater body of metal to give out heat.

Iron flasks are better than wooden ones in many cases, particularly where a large quantity of small machinery work is made. A simple type consists merely of two rectangular frames, each of which has on one pair of opposite sides two handles by which to lift it, and on the edge of the two pairs of opposite sides two pairs of lugs in such positions that a pin may be passed between them and the two flasks prevented from sliding out of perfect contact. They may be held together, if small, by two ⊓ shaped clamps and wedges, the bottom being made of boards with cross battons underneath, and held on by the same clamps which hold together the side frames.

SYSTEMATIC MACHINE DESIGNING.—I.

H. M. NORRIS.

Fifty or more years ago machines were usually designed by laying out and chalking the principal parts upon a huge improvised drawing board. These parts were drawn full size and were generally shown in plan and side elevation. Patterns were then made to correspond with the drawings and these parts cast and fitted, while all small pieces were left until the machine was set up, when measurements were taken, and the rest of the machine was designed and fitted on the cut-and-try system. But in these times of sharp competition, manufacturers cannot afford to take the chances of building expensive machinery which, upon completion, may prove of faulty design and only fit for the scrap pile.

Feeling that guesswork should be forever relegated to the past, and that a machine should be made correct, or nearly so, before it leaves the designer's hands—and that, too, before the drawing is black with age—it is my purpose to show how, by employing a little judicious thought, usually termed horse sense, a machine may be designed, step by step, from tool to countershaft, without once having to say: "I guess that will do."

Let us take, for example, the head stock of a 60-inch lathe, the general arrangement of which is shown in the sectional view, Fig. 1, in which A is the face plate carrying the internal gear B cut upon its back, C the internal gear pinion cut upon the end of the cone shaft D, to which is keyed the face gear E, H the back gear, keyed to the back gear shaft G, F the face gear pinion, cut upon shaft G and J the cone pinion, keyed to the cone, and forming the cone's bearing at that end. For slow speeds, and where greater power is required, the cone is left free to revolve upon its shaft, the power being transmitted through the back gears which will then occupy the position shown in the sketch.

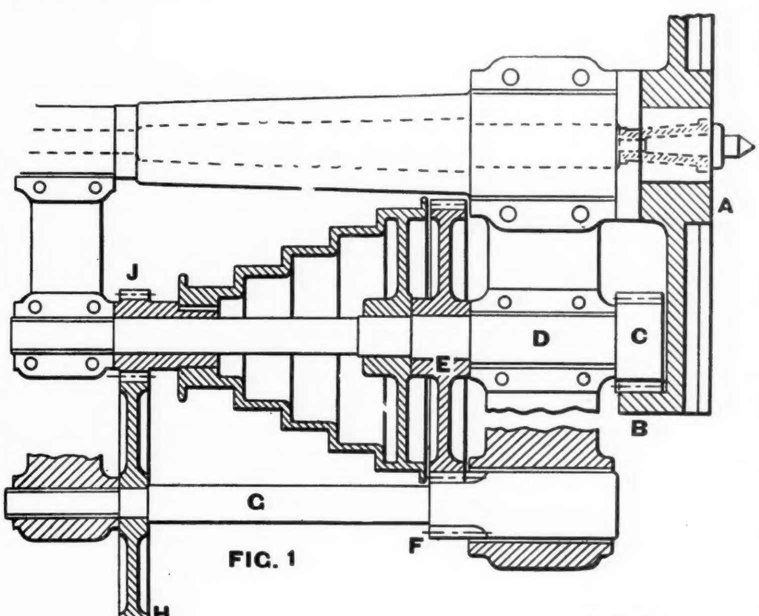

FIG. 1

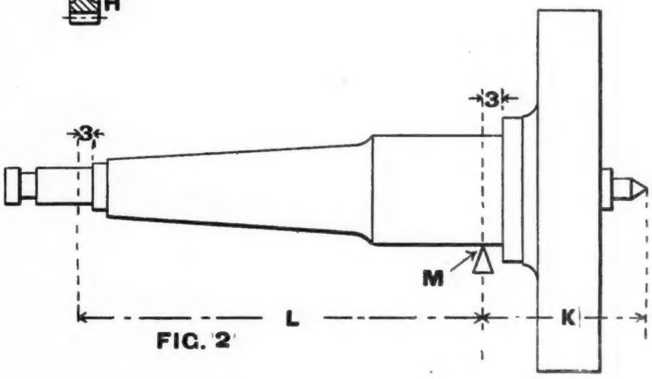

FIG. 2

1. *Power Required.*—The first step to be considered is the determination of the power that will be required to do the work. If we provide for sufficient power to remove the metal from the periphery of a 60-inch cast iron cylinder when taking a cut equivalent to the area of a chip ¾-inch deep with $\frac{1}{12}$-inch advance per revolution, it will, in all probability, be strong enough for the usual line of work given to a lathe of this size and class.

Deductions from experiments made at Sibley College, Cornell University and the Iowa Agricultural College, tend to show that, for average working conditions, 1 pound pressure on the tool will remove a chip of .0000052 square inches in cross section. The cross section of a chip ¾ x $\frac{1}{12}$ inches = .0625 square inches nearly. And .0625 ÷ .0000052 = 12019 pounds, about, which let us call 12100 the power necessary at the tool.

Before we can ascertain what gears will be suitable for obtaining this power, we must consider the main spindle.

2. *Weight upon the Main Spindle.*—Assuming that a hollow cast iron cylinder, 144 inches long, 48 inches in diameter and 10 inches in thickness, as the heaviest weight likely to be on the centers, we have area of section × length × .26, or 1193.81 × 144 × .26 = 44696.25 pounds as the maximum weight upon the centers. This will be divided between the head stock and tail stock spindles. Hence, half the above weight, or 22348.12 pounds, will be the weight on the live center, which, for convenience and extra safety, let us call 22,400 pounds.

3. *Diameter of Large Journal of Main Spindle.*—The spindle, which must have journals of large diameter so as to reduce the pressure per square inch of bearing surface to a limit of durability, should be made of cast iron, and since the strength of a hollow cylinder compared to that of a solid one of equal area of section is about as 1.65 to 1, depending upon the proportionate thickness of metal compared to diameter, we can, by coring the spindle, obtain the necessary strength without using a great mass of metal. The core should be large enough in diameter to clear the tool when boring the end of the spindle for its center bushing—assume it at 6 inches. The bending point of the spindle may be taken at a point 3 inches to the left of the right face of the large journal, and to allow for sufficient width of spindle collar and length of face plate bearing, the spindle will need to project about 19 inches to the right of the fulcrum. Then, to determine the diameter of our large journal, we must compute the outside diameter of a hollow cast irons cylinder, 6 inches inside diameter, and 19 inches long that will be strong enough, when fixed at one end, to stand a load of 22,400 pounds at the other end.

Cast iron under these conditions should not be subjected to a greater maximum fiber stress than 3,000 pounds per square inch.

Making R = maximum fiber stress
P = load.
L = length of cylinder.
D = outside diameter.
d = inside diameter.

And using the well known formula

$$R = 10.186 \frac{P\,L}{D^3 - d^3}$$

we have, by substituting our known quantities:

$$3{,}000 = \frac{10.186 \times 22{,}400 \times 19}{D^3 - 216}$$

$$\therefore D^3 = \frac{10.186 \times 22{,}400 \times 19}{3{,}000} = 216$$

and D = 11.84

which, for safety, let us increase to 12 inches.

4. *Length of Large Journal on Main Spindle.*—Experience has shown that journals working at high speeds require a greater length than those working at low speeds. Journals running at 150 revolutions per minute are often made only 1 diameter long; while journals for fan-shafts, running at 1,500 revolutions per minute are made 6 to 8 diameters long. For lathe spindles working at slow speeds, the journals are usually made from 1.25 to 1.5 diameters in length; which allows a margin for durability. Let us for trial in determining our journal pressure, assume a length between these figures—say 16 inches.

5. *Journal Pressure.*—The pressure on the bearing surface of crank pin journals range in different cases from 300 to 1,100 pounds per square inch. But in a lathe spindle, where the amount of wear figures so prominently in the value and accuracy of the machine, it is well to keep the pressure within 200 pounds per square inch.

If we let p equal the pressure per square inch of bearing surface, P the pressure on the whole area of bearing surface, and d and l the diameter and length of the journal, then the intensity of pressure upon the lower half of the journal box will be, roughly speaking,

$$p = \frac{P}{d\,l}$$

To find the value of P, let us consider the spindle as a lever

with its fulcrum at the bending point A, Fig. 2.

We have already assumed the length of the short arm, *k*, of the lever at 19 inches. The length of the long arm, *l*, depends upon the length of the headstock. Assuming the length of the large journal at 16 inches as before; width of face gear at 4 inches; length of five step cone suitable for a 5.5 inch belt and flange at each end at 29 inches; and allowing for a 3 inch face of pinion with a .25 inch clearance on either side of the back gear when slid out of mesh; and taking the bending point of the small end of the spindle at 3 inches to the left of the right face of that journal, we have:

$$(16 - 3) + 4 + 29 + 6.5 = 3 = 55.5 \text{ inches.}$$

as the length of the long arm of the lever.

Since the weight of the face plate, added to the weight of that part of the spindle at the right of the fulcrum, will about balance the weight of the spindle at the left of the fulcrum; we can, in considering our lever arms, disregard their weight. By the general rule for levers: "Power multiplied by its distance from the fulcrum is equal to weight multiplied by its distance from fulcrum," we have:

$$W = \frac{22,400 \times 19}{55.5} = 7,668 \text{ pounds about.}$$

which is the number of pounds that must be applied at the end of the long arm to balance the weight of the work coming upon the live center. Assuming that the spindle and face plate will weigh 2,000 pounds, we have:

$$22,400 + 7,668 + 2,000 = 32,068 \text{ pounds.}$$

as the pressure upon the large journals' box. Substituting this value of P in the formula:

$$p = \frac{P}{d\,l}$$

gives us:

$$p = \frac{32,068}{12 \times 16} = 167 \text{ pounds about.}$$

as the pressure per square inch upon the journal box; which is well within our limit of 200 pounds.

6. *Internal Gear.*—The internal gear B should be of suitable pitch and face to stand the pressure of 12,100 pounds applied at the tool, section 1, multiplied by the lever arms of the work and gear, Fig. 3, plus the necessary power to overcome the friction of the spindle.

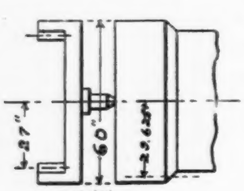

FIG. 3

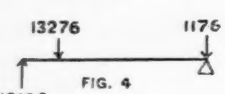

FIG. 4

The lever arm of the work, taking it to the center of action of the tool when taking a .75 inch cut, is 29.625 inches.

The lever arm of the gear is the radius of its pitch circle; which circle should be as large as possible so that for a given diameter of pitch circle of its pinion it will transmit a greater amount of power. Since the gear is cut upon the back of the face-plate, its outside diameter is limited to 60 inches; and being the last gear in the train, it must transmit sufficient power to overcome the resistance of the tool which will require a large pitch, hence we cannot have a much larger diameter of pitch circle than 54 inches without fear of destroying the strength of the teeth—let us consider 27 inches as the length of the lever arm of the gear.

With 29.625 inches and 27 inches as the lengths of our lever arms and the force of 12,100 pounds acting upon the end of the long arm in the direction indicated by the arrow, Fig. 4; also providing that there were no friction and that the several parts forming the lever were without weight, we would have

$$\frac{12,100 \times 29.625}{27} = 13,276 \text{ pounds}$$

as the power that must be applied upon the end of the short arm to overcome the resistance of the tool. In the lever, action and re-action must be equal and opposite; so

$$13,276 - 12,100 = 1,176 \text{ pounds.}$$

will be the pressure upon the fulcrum A, Fig. 4. The pressure upon the spindle journal-boxes we have already determined at 32,068 pounds, adding the pressure just found caused by the leverage, we have:

$$32,068 + 1,176 = 33,244 \text{ pounds}$$

as the whole pressure upon the spindle journal-boxes, which, if multiplied by .08 as the co-efficient of friction, will give us the friction of the spindle, or 2659.52 pounds—call it 2660 pounds.

We have made the large journal of our spindle 12 inches in diameter, let us assume the small one at 8 inches. Then their mean radii is 5 inches, which, if multiplied by the spindle friction and divided by the radius of the pitch circle of the internal gear, will give us the additional strain upon the teeth of the gear due to the friction, or

$$\frac{2660 \times 5}{27} = 492 \text{ pounds, nearly.}$$

Hence the whole strain upon the teeth of the internal gear is

$$13,276 + 492 = 13,768 \text{ pounds.}$$

To determine a suitable pitch for this gear, let us use Wilfred Lewis' formula for the strength of gear teeth:

$$W = s\,p\,f\,y,$$

where W = safe working load upon one tooth, s = safe working stress for different speeds, p = face of gear and y = factor of strength for the several forms of teeth given in table I.

By transposing—

$$p = \frac{W}{s\,f\,y}$$

Assuming the face of the gear at 5 inches and using the 20° involute form of tooth we have

$$p = \frac{13,768}{8,000 \times 5 \times .138} = 2.5 \text{ nearly,}$$

which is the circumferential pitch of a gear whose teeth will have the necessary strength to stand the strain of 13,768 pounds with safety.

In table III, which gives the proportional parts of gear teeth used by the Brown & Sharpe Mfg. Co., we find that 2.5133 is the nearest larger pitch to 2.5; so let us take it as the pitch of the internal gear. Then, with 54 inches as the approximate diameter of the pitch circle, as we found in section 6, we find that 68 teeth is the largest number that it would be safe to put in the gear.

TABLE III.

Diametr'al Pitch.	Circular Pitch.	Thickness of Tooth on Pitch Line.	Addendum and $\frac{''}{P}$	Working Depth of Tooth.	Depth of Space Below Pitch Line.	Whole Depth of Tooth.
P	P′	t	s	D″	s + f	D″ + f
½	6.2832	3.1416	2 0000	4.0000	2.3142	4.3142
¾	4.1888	2.0944	1.3333	2.6666	1.5428	2.8761
1	3.1416	1.5708	1.0000	2.0000	1.1571	2.1571
1¼	2.5133	1.2566	.8000	1.6000	.9257	1.7257
1½	2.0944	1.0472	.6666	1.3333	.7714	1.4381
1¾	1.7952	.8976	.5714	1.1429	.6612	1.2326
2	1.5708	.7854	.5000	1.0000	.5785	1.0785
2¼	1.3963	.6981	.4444	.8888	.5143	.9587
2½	1.2566	.6283	.4000	.8000	.4628	.8628
2¾	1.1424	.5712	.3636	.7273	.4208	.7844
3	1.0472	.5236	.3333	.6666	.3857	.7190
3½	.8976	.4488	.2857	.5714	.3306	.6163
4	.7854	.3927	2500	.5000	.2893	.5393
5	.6283	.3142	.2000	.4000	.2314	.4314
6	.5236	.2618	.1666	.3333	.1928	.3595
7	.4488	.2244	.1429	.2857	.1653	.3081
8	.3927	.1963	.1250	.2500	.1446	.2696
9	.3491	.1745	.1111	.2222	.1286	.2397
10	.3142	.1571	.1000	.2000	.1157	.2157
11	.2856	.1428	.0909	.1818	.1052	.1961
12	.2618	.1309	.0833	.1666	.0964	.1798
13	2417	.1208	.0769	.1538	.0890	.1659
14	2244	.1122	.0714	.1429	.0826	.1541
15	.2094	.1047	.0666	.1333	.0771	.1438
16	.1963	.0982	.0625	.1250	.0723	.1348
17	.1848	.0924	.0588	.1176	.0681	.1269
18	.1745	.0873	.0555	.1111	.0643	.1198
19	.1653	.0827	.0526	.1053	.0609	.1135
20	.1571	.0785	.0500	.1000	.0579	.1079
22	.1428	.0714	.0455	.0909	.0526	.0980
24	.1309	.0654	.0417	.0833	.0482	.0898
26	.1208	.0604	.0385	.0769	.0445	.0829
28	.1122	.0561	.0357	.0714	.0413	.0770
30	.1047	.0524	.0333	.0666	.0386	.0719
32	.0982	.c491	.0312	.0625	.0362	.0674
34	.0924	.0462	.0294	.0588	.0340	.0634
36	.0873	.0436	.0278	.0555	.0321	.0599
38	.0827	.0413	.0263	.0526	.0304	.0568
40	.0785	.0393	.0250	.0500	.0289	.0539
42	.0748	.0374	.0238	.0476	.0275	.0514
44	.0714	.0357	.0227	.0455	.0263	.0490
46	.0683	.0341	.0217	.0435	.0252	.0460
48	.0654	.0327	.0208	.0417	.0241	.0449
50	.0628	.0314	.0200	.0400	.0231	.0431
56	.0561	.0280	.0178	.0357	.0207	.0385
60	.0524	.0262	.0166	.0333	.0193	.0360

TABLE II.

SAFE WORKING STRESS, S, FOR DIFFERENT SPEEDS.

Speed of Teeth in Ft. per Minute.	100 or less.	200	300	600	900	1,200	1,800	2,400
Cast iron.....	8,000	6,000	4,800	4,000	3,000	2,400	2,000	1,700
Steel.........	20,000	15,000	12,000	10,000	7,500	6,000	5,000	4,300

TABLE I.

Number of Teeth.	Factor for Strength, y.			Number of Teeth.	Factor for Strength. y.		
	Involute 20 degrees Obliquity.	Involute 15 deg. and Cycloidal.	Radial Flanks		Involute 20 degrees Obliquity.	Involute 15 deg. and Cycloidal.	Radial Flanks
12	.078	.067	.052	27	.111	.100	.064
13	.083	.070	.053	30	.114	.102	.065
14	.088	.072	.054	34	.118	.104	.066
15	.092	.075	.055	38	.122	.107	.067
16	.094	.077	.056	43	.126	.110	.068
17	.096	.080	.057	50	.130	.112	.069
18	.098	.083	.058	60	.134	114	.070
19	.100	.087	.059	75	.138	.116	.071
20	.102	.090	.060	100	.142	.118	.072
21	.104	.092	.061	150	.146	.120	.073
23	.106	.094	.062	300	.150	.122	.074
25	.108	.097	.063	Rack.	.154	.124	.075

* * *

CONDUCTING TESTS.

W. H. Wakeman.

To a disinterested party, it is often amusing to hear the reports of tests conducted to determine certain things, and to note the careless way in which said tests were carried on and reported. The most common case of this kind is where it is desirable to know which of two or three kinds of coal is the most economical to use to run a certain plant. Many times when a test of this kind is to be conducted, all that is done is to note the number of tons of one kind of coal that are required to run the plant a week, and then try another kind for another week. The engineer may protest that such a trial is not fair, but the proprietor says that he does not care for the fine points, as all that he wants to know is which kind will run the plant a week for the least number of dollars. It is quite possible that the load is not the same in both cases, the feed water may be colder at one time than at another, and unequal amounts of live steam may be used, but it is all the same to the fellow who sits in the office and sends forth ultimatums. Such a course is not only unfair to the coal dealer, but unsatisfactory to the steam user, or would be if he cared to investigate the matter. Even where an engine is running with apparently the same load from day to day, it is quite possible that it will not be the same for two days in succession.

Again, if the feed water is not at the same temperature during both weeks or days, it will affect the result, and the manner in which the coal is handled will also make quite a difference.

A certain steam user became dissatisfied with the coal that he had been using and wanted to make a change, if he could do so for the better. He procured a water meter and connected the water pipes to it so that all water going to the boiler must go through it. This constituted the sole outfit for making a test that was to determine which coal was best and cheapest, where several thousand dollars were involved.

The number of cubic feet of water indicated on the dial and the number of pounds of coal brought on to the premises, were all of the quantities noted and when the pounds of water indicated by the meter were divided by the number of pounds of coal delivered the quotient was the fatal number that decided who was to furnish the coal.

There is but one thing about such a test to recommend it, and that is its great simplicity, for it excels all others in this respect; but here its superiority ends. Part of the steam was used for running an engine, a part for running pumps, and the remainder for heating vats of water by blowing it directly into them and in keeping dry rooms at a high temperature by means of the ordinary coils and banks of pipe.

In the first three cases mentioned the steam was entirely lost, but in the latter the water of condensation was returned to the boilers at a high temperature. If large quantities of steam were used in the vats the temperature of the feed water would be reduced, for it was heated by the exhaust from the engine, and the load was light at times. No account was made of the quality of the steam, nor was the amount of coal wasted by passing through the grates unburnt, taken into consideration, neither was the moisture in the coal accounted for. Such tests are not very satisfactory to any one who has given the subject the attention that it deserves.

Trusting to a water meter is bad enough, but the following plan is much worse.

A certain engineer calculated the amount of water that his boiler would contain, for the difference between a low water mark on his gage glass and a high water mark on the same glass, and even went so far as to measure the water to prove the calculation, taking the water when cold and pouring it into a cold boiler. It will be noted that when cold water is running into a boiler, the water in the glass does not rise steadily but goes up by irregular jerks, unless the glass is coated with something to prevent it.

This shows that it is difficult to locate the water line with accuracy and a difference of even an eighth of an inch will affect the results seriously. After this engineer had located these lines for measurement, he fired up his boiler with the water line at the high water mark then let it run until it was evaporated down to the low water mark, and charged the number of gallons that the difference called for.

In addition to the difficulty of locating the exact water line in the glass, it will be noted that there is a difference in the bulk of cold and hot water, and consequently a given space will not contain as much weight of hot water as it will of cold, even when the hot water is under pressure, for water is not compressible to a degree that will make up for the difference. Is water compressible?

I once referred this question to a man who is well educated as a mechanical engineer and his reply was to the effect that when water was compressed into a solid body, it could be compressed no more, but so long as it remained a liquid there is a chance to get the particles a little closer together. I thought the reply well worthy of consideration. It is quite evident that such a boiler test as the above is simply worthless.

While conversing with a man who has studied up something of the theory of the action of water under pressure, etc., but who was not what may properly be called a practical man, the subject of conducting boiler tests was mentioned, and he expressed the idea that it was a good plan to take a week for the purpose in order to cover all points.

These particular boilers were fitted with a patent setting, consisting in part of pipes located along the side walls of the furnaces, and these pipes must be blown out daily while in use in order to prevent the accumulation of scale. I asked him how he would manage that part of it and his reply was that it was an easy matter to calculate the amount of water that would flow through a pipe of given size, during a given time under a known pressure.

Now this setting was fitted with the slow opening gate valves requiring nine turns of the wheel to open or shut them, and were so large that they could be left open but a few seconds, as the pressure was high. It required fully as much time to open and shut these valves, as could be allowed for leaving them wide open, consequently I doubt very much if any man could tell how much water was blown out unless he caught and measured it.

A certain engineer in charge of a medium sized engine, began to experiment with cylinder oil, and he found it possible to get along with one pint less per day than he had been using, but in the meantime the fireman had been experimenting with coal and repeated trials convinced him that while one pint of oil was saved, about one half ton more of coal was required to drive the machinery. He had no way of determining the exact amount of power developed, it is true; but the difference in coal was great, and repeated trials all gave the same general result, which entitles the report to at least some consideration.

In another case an engineer had been running with no back pressure above the atmosphere on his engine, but changes were made which called for a back pressure valve on the exhaust pipe. This was weighted so light that the additional back pressure could not have exceeded two pounds per square inch, and yet he imagined that it brought great additional strain on the working parts of his engine. This is ludicrous, not only on account of the slight back pressure added, but because the addition of back pressure does not tend to increase the strain on the working parts. It is true that to increase the back pressure has the same effect on the consumption of steam as if more machines were added in the mill or factory, but a little consideration of the way which back pressure acts on the piston, or in other words of the way that this load is applied, will make the matter plain.

One of the most simple things that I have ever heard of being discussed by working engineers, is the following question.

Suppose that you have a high pressure on your boiler, and start the direct acting feed pump, letting it run long enough to get settled down to a uniform speed, then note the number of strokes per minute. If the boiler pressure falls, will the speed of the pump be increased or decreased? There was a difference of opinion, which could only be explained by concluding that if the speakers had ever tried it, the experiments must have been performed under different conditions.

I was asked to conduct a test to decide the matter. A pump was taken that was fitted with a sight feed lubricator, so that the supply of oil might be uniform, also that the rate of feed could be accurately noted. The water was supplied under pressure from the city mains, and a gage was connected on each side of the pump, so that both supply and delivery pressure could be observed. At the beginning of the test the steam pressure was 58 pounds, pressure in delivery pipe 61 pounds, pressure in supply pipe 21 pounds, number of strokes per minute 32, and throughout both tests one drop, approximately, of cylinder oil ascended per minute, the variation being but a few seconds, and the pressure in delivery pipe exceeded the steam pressure by from 2 to 5 pounds according to speed of pumps. The pressure in supply pipe varied from 21 to 18 pounds at different times during the test.

The fire was banked, and when the pressure had fallen to 50 pounds the pump was making 34 strokes and observations were made for each fall of 5 pounds in pressure until it was down to 20.

At 45 the strokes were 34, at 40 the number had fallen to 32, and at 35 they were increased to 38. At 30 and 25 they were 41, and at 20, 42 were noted.

The pressure was then raised to 58 pounds again, and observations made for increase of pressure the same as for the falling. When it had reached 58 the pump was making 31 strokes per minute. From this it will be seen that the strokes increased with a falling steam pressure. The experiment was repeated under the same conditions except that the pump took its supply from a tank, the lift being 8 inches. At the highest steam pressure, the speed was 35 strokes per minute and when it had been reduced to 20 the pump was making but 10 strokes.

When the steam pressure was again raised, the pump made 33 strokes per minute. Under these conditions the number of strokes was decreased with a falling steam pressure.

One reason that I have for giving these figures is to show that if a test is to be conducted at all, it should be done carefully and every detail noted, even in a case of small importance like this, as otherwise the results are of no value.

There are several matters concerning the lubrication of engine bearings and of shafting that might be mentioned, but only one will be brought up as it is of common occurrence. Perhaps the shafting in a shop has been run with oil for several years, but suddenly a spirit of reform strikes the superintendent, and grease must be used instead. Now I would not wholly condemn the use of grease, for I often use it myself and believe it to be a good thing, but it should be used and not abused. An oil agent, who also sold grease and lubricating compounds, called on a mill owner who had been one of his customers, to ascertain if more shafting grease was wanted, and was informed that some of another kind had been purchased. He naturally asked the cause for the change, was told that another party sold grease cheaper than he could, promptly denied the allegation, and stated that he could sell the article at all prices down to 3 cents per pound. It may be unnecessary to add that few mill owners who have given the matter any consideration will expect to get a 10 cent grease for 5 cents per pound, and those who do will find themselves mistaken.

The cheaper grades of grease, of the heavier kinds, often become dry and hard in the boxes, and will not run down on to the shaft until it becomes quite warm; and furthermore, because a shaft does not heat, is not positive evidence that it is running with the least amount of friction. Well our superintendent orders some cheap grease and orders it used instead of oil. The result is that the expense is less than for oil, and the oiler has time to do other work; but this test is very incomplete and may be misleading, for it is quite possible that after the grease has been used for several months, the shafting will require more power to turn it, and the cost of this may exceed the entire cost of the oil used, plus the wages of the oiler.

Let us not be hasty in arriving at conclusions, but make all of our tests carefully and be sure that every point is covered.

* * *

Don't take chances with moving machinery—doesn't pay.

HANDY DRAUGHTING TOOLS.

G. Edward Smith.

In a draughtsman's life there are so many little annoyances in the shape of petty jealousies from the shop hands and the showing of authority by those in higher positions in regard to details of minor importance that so far as possible he should be free from petty annoyances caused by ineffective tools, therefore the schemes such as I mention here and many similar ones, seem to me of

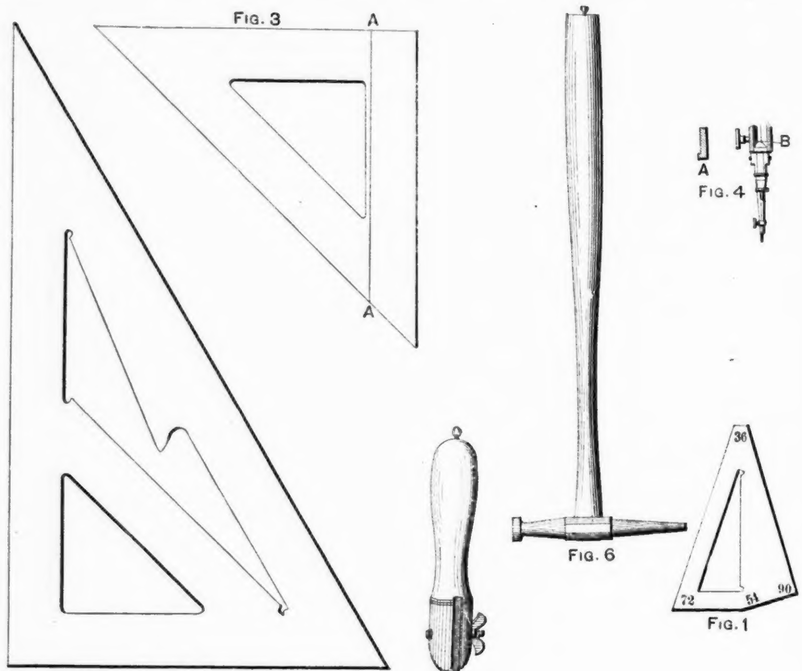

Fig. 3 Fig. 4 Fig. 6 Fig. 1 Fig. 2 Fig. 5

almost paramount importance to the mental well-being of a draughtsman.

First among them I mention a triangle of my own design and which so far as I know has never been used before. It is for dividing a circle into 20, 10 or 5 equal parts and is made as shown in Fig 1 of celluloid and has proven quite a useful device. Apart from its transparent qualities celluloid is particularly good on account of its cleanliness. It does not rub off as does the hard rubber, which soils the paper most unmercifully. My experience has been that it keeps its accuracy fully as well if not better than rubber or wood, the latter, while fairly clean, are more liable to become inaccurate.

Another design for a 16 inch 60 symbol triangle is shown at Fig. 2. This was designed by a friend of mine. It is a very useful one and should in my opinion be more generally used. Having the 45° angle, it saves a change of triangles for but one or two lines. The other angles 22½, 67½ and 7½° while useful, are not so much so as the 30, 60, 45, and 90°. It is frequently necessary to draw to a certain point. To accomplish this quickly I have scratched a a line as shown at A A Fig. 3 on my celluloid angles parallel to one side and at right angles to another. By placing this line over the original line with its edge on the point, the required line can be drawn accurately.

One of the most trying things to a draughtsman is the constant dropping of the trammels from the bar in adjusting. To obviate this I have made my bar with the section A Fig. 4, filing off the bottom of clamp plate as shown at B Fig. 4. This should be done by the makers of the instruments, but it never seems to have appealed to them and they have used many more complicated and generally less satisfactory means, which add considerable to the price.*

The use of a sand rubber holder, a simple and effective form of which is shown in Fig 5, is highly recommended both as a saving of fingers and rubbers, in connection with which a thin sheet of copper plate with slots and openings of different sizes and shapes whereby a figure or line may be erased without destroying adjoining work The one shown is a handy article.

I am a thorough advocate of the use of small 1 ounce tacks, instead of thumb tacks, as they interfere much less with the free use

* This is now being done by at least one maker of drawing instruments that we know of.—[Ed.

of the T square and triangles than do the thumb tacks. They are easily withdrawn with a knife blade or small thumb tack lifter. Fig. 6 shows a neat hammer to use with them, made of $\frac{5}{8}$ inch octagon steel and about $4\frac{1}{2}$ inches long, the point being about $\frac{3}{16}$ in. and the pene $\frac{9}{16}$ inch in diameter. This, if magnetized, can be used to pick up and to drive in tacks without the use of the figures.

Fig. 7 shows a flat rule designed and used by myself which contains the scales most needed by draughtsmen. As seen it has the scale of 6 in. to 1 ft. frequently needed for detailing of small parts and yet seldom included on the engineers' scales. This section has up to the present been little used on this side of the water, though I understand it is almost universally in Europe. It is much better than the plain flat kind, both as to wear and use. Taking it in the fingers it can be easily held so that the scale is close to the paper, and being flat it does not get turned over as does the triangular when laid down, nor does it wear the edges destroying the divisions as do the latter. It must of course be made to order. As the scale of chords cannot be divided by American makers owing to lack of machines it has to be made abroad and can be obtained at very reasonable rates.* In using the scale of chords the distance from 0° to 60° is taken in the compasses and an arc described.

The distance from 0° to the degree wanted is then laid off as a chord on this arc, giving the angle by connecting these points with the centre. It is more accurate than marking from a protractor and just as quickly done. The scale is divided into half degrees. The triangles described, I made from sheet celluloid.

* * *

STRENGTH AND WEAR OF GEAR WHEEL TEETH.

BELL CRANK.

Several writers have presented articles on the above subject in your paper during the year, yet it seems to the writer that none of your contributors have fully informed themselves of the available knowledge extant on the subject. Joshua Rose, in "Machine Shop Practice," pointed out the fact that to find the actual section of a gear tooth, which is the weakest point when subject to working stress, it was necessary to consider the tooth as a beam loaded at the end, and to plot the greatest parabola that could be enclosed in the actual tooth outline. Any one who will take the trouble to do this on a rack-tooth and a twelve-tooth pinion of the interchangeable cycloid system, will at once discover that the rack-tooth is more than double the strength of the pinion tooth of same pitch.

Over two years ago Wilfred Lewis developed this plan into practical working rules, and presented the results in a paper read before the Engineers' Club, of Philadelphia. This was the first attempt to produce a rational system of calculating the strength of gear teeth that the writer knows of having been made public. About the same time, the writer made an attempt to construct a single formula that would include the number of teeth in the wheel as a factor to express the variation in strength from the twelve-tooth pinion to the rack. This incited Mr. Lewis to improve his formula so as to dispense with the table of tooth numbers and factors, and use a single simple formula for each system of tooth curves. In this form I think it is the most correct formula that has yet been offered for the purpose, and it is simple enough not to be objectionable to practical men.

Mr. Lewis took as a basis for his calculations that the load was sustained by the point of a single tooth, being applied equally across the width of face. The addendum was taken at .3 pitch, the root .35 pitch and clearance .02 pitch. The fillets at root of pinion teeth were made as large as possible and to clear points of teeth of an engaging rack. This matter of fillets is very important, and their omission will in some cases diminish the strength 15 per cent.

W = working strength of tooth in pounds.
s = tensile stress of material per square inch in pounds.
p = circular pitch of teeth in inches.
f = face of teeth in inches.
v = velocity at pitch line in feet per minute.
n = number of teeth in wheel.

For 15° involute and the interchangeable cycloid systems:

$$W = s\,p\,f\left\{.124 - \frac{.684}{n}\right\}$$

For 20° involute:

$$W = s\,p\,f\left\{.154 - \frac{.912}{n}\right\}$$

$$\text{H. P.} = \frac{W\,v}{33{,}000}$$

In the interchangeable cycloid system without fillets the rack-tooth is 2.8 times as strong as the tooth in a twelve-tooth pinion, and a twenty-tooth wheel is almost twice the strength of the pinion. It is very obvious, therefore, that any formula for gear teeth strength which leaves out this factor, will not in many cases give any nearer the correct results than an experienced man could reach by guessing. Any one interested in the subject should get the original paper by Mr. Lewis, for the method of reaching the formula is so lucidly explained that any one with only fair mathematical ability can adapt a formula for other systems or proportions of teeth than those given. I should perhaps note that the foregoing formulas will not give the breaking strength of the tooth, but are correct when S does not exceed the elastic limit of material.

Some rules for strength of gear teeth are arranged to give a pitch that will sustain the desired load on one corner of the tooth. There are of course certain conditions which will require this, but in all such cases it is useless to make the face more than one and one-half times the pitch, for any more face would seldom be in contact on a wheel liable to do most of its work on the tooth corners. It will also be perceived that any increase of face for wear would be equally useless under like conditions, so that the best that can then be done is to assume the face at one and one-half times pitch and increase the pitch until it will sustain the desired load, and if the pressure is such as to cause rapid wear, use as good material as possible, and if conditions cannot be improved, become resigned to the fact that such wheels must be frequently renewed.

In regard to the wear of gear wheels, there is not much hope of getting many persons to consider it, for it is strictly an economic question. Any one who intends to use gear wheels, no matter how limited are his financial resources, understands that gears will be useless to him unless they will do the required work without breaking, and he therefore will insist on this point, but when it comes to the matter of durable wearing qualities, this can be attained only by an increase in the first cost, and the more durable the wheel is made, the longer he will have to wait to realize the full value of the increased durability.

Where the strength of teeth is assumed to be directly proportionate to the pitch, it is obvious that there must be a definite proportion of face to pitch which will give the maximum allowable pressure per unit of wearing surface, and if this proportion is established and adhered to in all cases, then as soon as the pitch and face strength required to do the work is calculated, the result at once decides the width of face for durable wear. The friction of wheel teeth is not different from any other sort of slid-

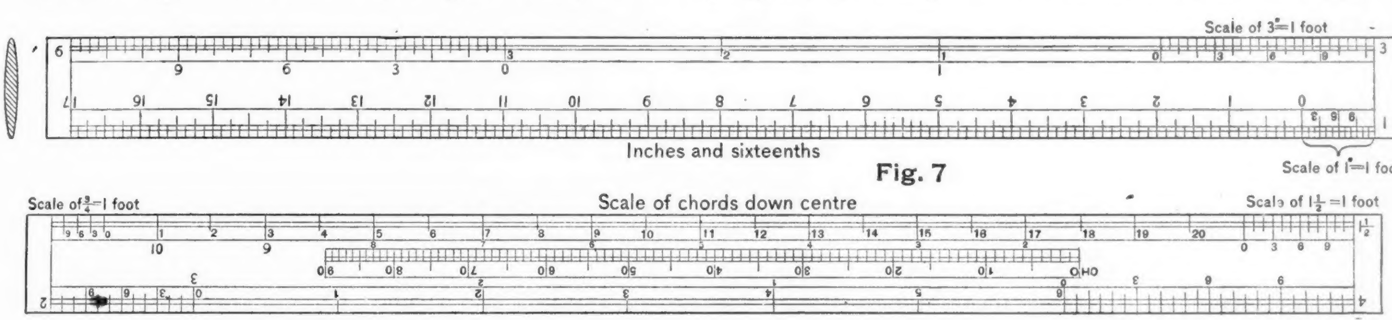

Fig. 7

* This scale was made for me by Aston and Mander of London, England, and the more I use it the better I like it.

ing friction, and if the teeth are well fitted and properly lubricated, their friction and durability will be similar to that of journals. Wheel teeth have one favorable condition that journals lack, in that the heat generated by the friction has plenty of time to radiate while the teeth are out of action. Considering a sliding piece like an engine crosshead, in figuring for area of bearing on the guides, only the pressure per square inch is considered, and when this is kept within the limits that will permit thorough lubrication, it will have the required durability no matter whether it makes 20 or 200 strokes per minute.

In your June and October issues, a rule for computing the wear and pitch of gear teeth is given, and an example figured by them may be interesting:

W=pressure in pounds.
S=tensile strength of material per square inch.
A=co-efficient of wear.
n=number of revolutions per minute.
p=pitch in inches.
f=breadth of face in inches.

$$f=\frac{W\times n}{A} \qquad p=\frac{16.8\times A}{S\times n}$$

Example: $W=500$. $n=60$. $A=30{,}000$. $S=1{,}000$.

$$f=\frac{500\times 60}{30{,}000}=1 \text{ inch.} \qquad p=\frac{16.8\times 30{,}000}{1{,}000\times 60}=8.4 \text{ inches.}$$

A wheel of 8.4 inches pitch and 1 inch face may be suitable for such requirements, but no one with any experience would use such a wheel for the place, simply because of the absurd relation between pitch and face. It may be said that S should be taken higher for such slow speed, but even if S is taken at 4,000, the pitch will be 2.1 inches, and is still too much for 1 inch face. But this is not the worst point about it, for a stress of 500 pounds on a face of only 1 inch cannot be considered as favorable for lubrication and wear, since it is not possible for it to have an actual bearing of more than one-quarter of a square inch, which would then make the pressure per square inch 2,000 pounds. This shows that there are other factors besides pressure and number of revolutions which must be considered. The fact is that there is a certain pressure per square inch of contact surface that will permit thorough lubrication and avoid abrasion, and if this is exceeded, the teeth will wear rapidly, even though the speed be slow, and it therefore follows that the face should never be less than a fixed proportion to the pitch, regardless of speed. It does not follow that speed need not be considered, for unless perfectly lubricated there will be some wear on the teeth, and this wear will be directly as the number of revolutions, and the more imperfect the lubrication the more important the effect of speed. It is apparent, therefore, that a co-efficient of lubrication, as well as maximum allowance of pressure per square inch of contact, must be made factors of a correct formula for wear. There is lack of available data on these points, and I therefore suggest that if any readers know of wheels in service long enough to have a measurable wear, it would be to the interest of the vocation to contribute the particulars to your paper. It is necessary to know the pitch and face, number of revolutions and diameter or number of teeth in gears, kind of material, amount of wear, time in actual service, and particularly the average load transmitted; also conditions of operation as to lubrication and exposure to various elements.

* * *

OILING LONG DRILLS.

Sometimes it is necessary to make a very long drill-hole of comparatively small diameter; and in doing this the work goes bravely on for the first few feet, but after that there is not only the trouble of backing out to get rid of the chips, but the nuisance of having to oil the cutting portion. In the Pratt & Whitney shops the latter trouble is done away with by forming along the drill a flute or channel, straight or spiral, according as the drill is or is not of the twist type; and then by brazing in a strip of brass, closing up this channel externally so that it acts as a duct for oil, while at the same time not catching any chips. Externally it is turned off true with the outside surface of the drill itself, so that it offers no obstruction in working. Oil is forced in, and comes out with the chips.

This is not a cheap tool to make, but it is much cheaper to use it than to have the tool break in the hole.

Apropos of long drilling, the Bement & Miles Company, in making a small 35-foot long hole, three-fourths inch in diameter through a cutter bar for "Uncle Sam," ran in 17½ feet from each end, the two bores meeting in the middle, and being only one-thirty-second of an inch out of axial exactness. The object in this case was merely to lighten the bar.

* * *

PATTERN SHOP SUPPLIES.—(2.)

JOHN M. RICHARDSON.

BURNING IRONS.

A set of these is an acquisition to any shop, and the taper can be about one inch in eight inches. They are very handy when we wish to have a hole make its own core, for they make a good draft on the sides in the quickest manner possible and form a surface which leaves the sand easily. To have the burning iron last and do good service, keep it clean and do not under any consideration heat it hot enough so that it will scale. A cherry red is amply sufficient.

STRAINERS.

Shellac should in all cases be strained when first mixed before using, and so should glue occasionally, for bristles and hard particles from the sides of the pot surely find their way into it and a skin forms over the surface unless the glue pot is in constant use. For shellac I have used nothing better than ordinary cheese cloth, a yard of which costs five cents, and makes quite a number of squares sufficiently large to strain through; the beauty of this kind of a strainer is, that it costs so little and can be immediately thrown away as soon as used. It can also be used for glue, but it is a little fine for that, and a wire strainer does fully as well if a little care is taken to keep it from getting clogged up after using.

WIRES FOR LOOSE PIECES.

It is well to have a good supply of these on hand, and two sizes are useful, one from ⅛ inch wire and the other from $\frac{1}{16}$ inch. Coppered iron wire is preferable for them, as the dampness they are subjected to in the foundry will not rust them as quickly. The larger size can be cut 6 inches long and the smaller 4 inches, then point them all on a coarse emery wheel, and next bend the blunt end of the larger ones over 1 inch at a right angle and the smaller ones ¾ inch. The little ones can be most easily bent by taking a number and placing the ends of all at the same time in the jaws of a vise and then hammering them over, but the other size is best done as follows: Take any block of iron having some weight and drill a hole in it 1 inch deep, it being a loose fit for the wire. Now place a wire in this hole and with the left hand bend it over quite a distance, next give one quick blow with a hammer on the top of the bend with the right hand and the wire is completed, having a right angle, and all will be exactly alike, as the hole acts as a gauge for the length of the bent portion.

DOWEL PINS.

Many shops still use the long stick dowels, cutting them up as occasion requires for the patterns, but this is hardly good practice for first-class work at the present time, for there is one great drawback to their use, and that is, that no matter how nicely the pins may fit when the pattern leaves the shop, they will be sure to stick and bother the moulder as soon as they become dampened, and on the other hand by long continued use they become so loose that the halves of the pattern will shuck by each other and make an unsatisfactory casting for which the flask is not accountable.

Brass dowel pins for small work give most excellent results, while for heavy jobs large cast iron ones are generally used. The brass ones just mentioned can be bought from dealers in pattern supplies, and consist of the pin or peg part fitting to a socket in its mate, and one size of hole in the work answers for both parts of the dowel. Both pieces have grooves cut on the outside in such a manner that they drive in easily but come out very much like pulling a tooth.

DRAW PLATES.

No rule can be laid down for the sizes of these pattern savers (for that is in reality what they are), as a large pattern without them gets split and defaced very quickly. They can be of any size best adapted to the pattern, but for ordinary work I like those that can be put in with an extension bit, thus fitting a round hole, this saves much time. Medium sized ones need have only a draw hole tapped out with a coarse thread, the rapping being done against the draw handle. For heavier work it is better to have both rap and draw holes, and also have the plate with a shoulder of smaller diameter on the bottom. This necessitates boring two holes, but they both have the same center, and it takes but little

time, and this is repaid by the plate having a firmer hold in the pattern. One point in this connection it is well to remember, and that is to use *long* screws whenever possible in putting in draw plates, for continual rapping quickly loosens short ones.

LEAD HAMMER.

There is always more or less pounding being done about a lathe,

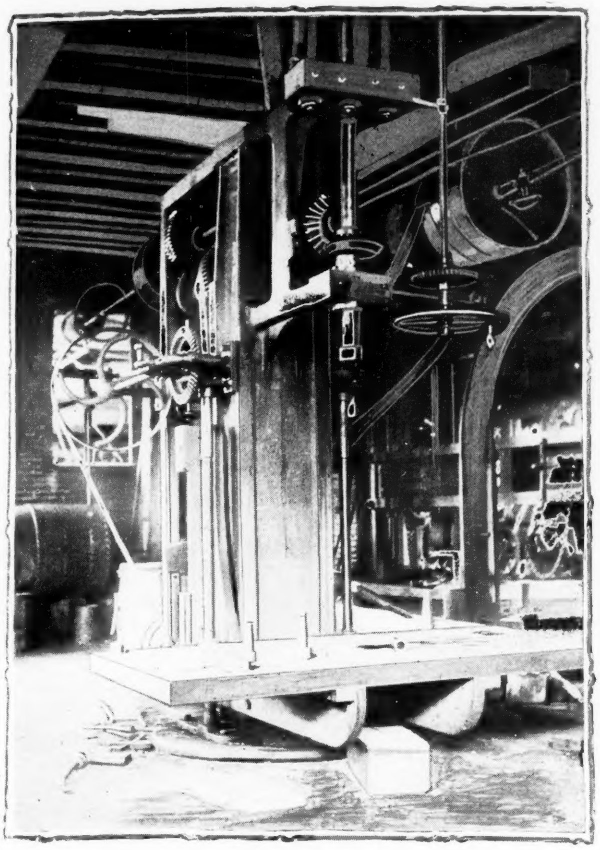

FIG. 8—OBSERVATIONS IN AN OLD SHOP.—SEE PAGE 198.

sometimes in removing centers and sometimes in driving them into the work and in various other ways, so the only method to keep a lathe from getting battered up is to furnish a lead hammer and keep it right in sight, on or near the lathe, and not to allow either lathe or centers to be pounded with anything else.

BRUSHES.

These are needful both for glue and shellac. Most pattern makers prefer a camel's hair brush for shellac, and some like one of very soft bristles better. For glue, the brush can be pretty coarse and not of very good quality, provided, however, it is so made that the bristles will not come out while in use. In some places they make glue brushes out of basswood bark. This is extremely fibrous, and if a piece be whittled into the shape of a brush and well pounded on the end and soaked in hot water, it becomes very soft and hairy, and really makes quite a fair brush. It has the merit of not costing anything at all events.

FILES.

While these are not as much needed as in the machine shop, still they are necessary for band and circular saws, finishing metal patterns, etc., and must be kept on hand.

AMMONIA.

This is for cleaning old pattern letters and figures so they can be used again. If boiled in aqua ammonia for a few minutes and then thoroughly stirred and rinsed they will come out looking almost like new.

SILVER SOLDER AND BORAX.

The time comes when every band saw must break, so it is well to be prepared and have the materials on hand to braze it. The brazing clamps usually come as a part of the band saw, so they hardly need mentioning here. The borax should be pulverized, and the silver solder placed between the two laps of the joint on the broken saw. Powdered borax is better to use than acid and cleaner to handle.

MATERIALS FOR FINISHING IRON PATTERNS.

Some blue vitriol dissolved in water, with a little nitric acid added, makes a surface on an iron pattern that will draw better than the bright metal, and bayberry tallow cut with turpentine and rubbed over, after the blue water just mentioned, makes an elegant finish, superior to beeswax.

COLORS FOR MARKING PATTERNS.

Vermilion mixed with shellac makes a very bright varnish to use for marking and numbering, but as the vermilion is so heavy it has to be stirred a good deal. Venetian red is very much cheaper but not so bright, and is a good deal lighter and requires less stirring to prevent settling. White lead can be mixed with the shellac for marking black shellaced patterns.

BELT LACINGS.

For belts passing over very small pulleys at a high rate of speed, as on circular saws and planers, the unavoidable bunch on the under side is detrimental, for it occasions a pound or thump every time the spot passes over the pulley, and for that reason I am favorably inclined toward the steel belt lacings that have small teeth which go through the belt and clinch on the under side, presenting practically the same belt surface to the pulley as though it was cemented.

SAND BOX.

While this does not come under the head of pattern shop supplies, still a large box of moulding sand is a very nice thing to have in a pattern room, for very often on small work there are places which look a little uncertain as to how they will draw, and loose pieces often come under conditions where it is somewhat difficult to see whether they can be removed easily or not, and a pattern maker likes to feel sure on a doubtful point before the work leaves his hands.

* * *

SCREWING PIECES TOGETHER.

The ordinary practice of laying out and doing work where one piece has to be fastened to another by two or more screws is to lay out the centers for the bolt-holes and tap-holes by cross-marks which are then prick-punched, and the holes are next drilled and tapped. The holes may or may not be accurately spaced, so that the pieces go together with greater or less difficulty, and sometimes one screw pulls one way and another in another direction. Then, according as one or the other screw is tightened first, the

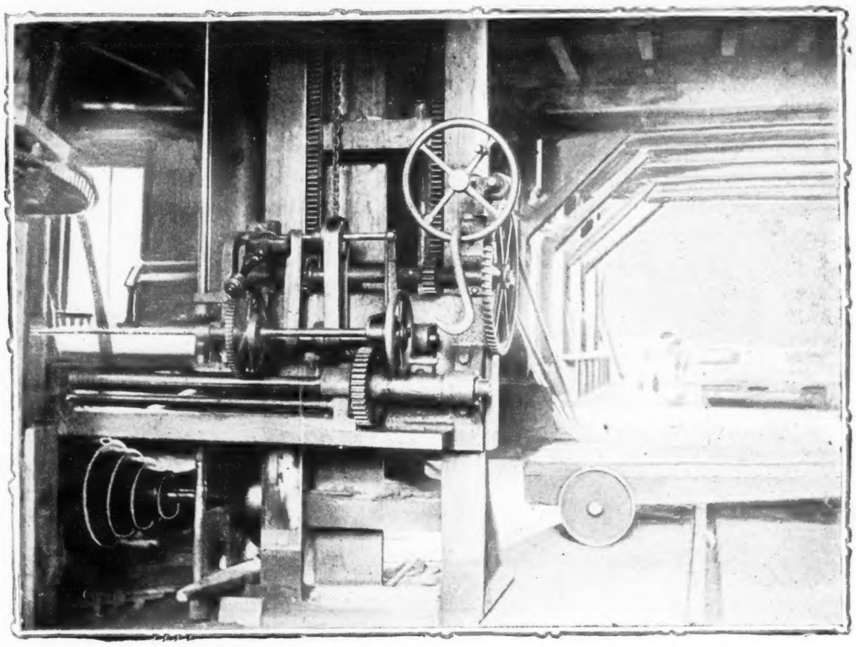

FIG. 9—OBSERVATIONS IN AN OLD SHOP—SEE PAGE 198.

part assumes different positions. If the holes are made considerably too large, there may perhaps be less trouble about assembling, but more as regards the firmness of the machine when put together.

In the Bilgram shops, in Philadelphia, the practice is much

better than this. There, only one of the tap-holes is tapped at first; then screwing the part to be held in place, by this one screw, tap the remaining holes, letting the full-sized holes act as guides for the tap.

This method of procedure takes a little longer at first, but in the end it pays by reason of the superior accuracy of the work.

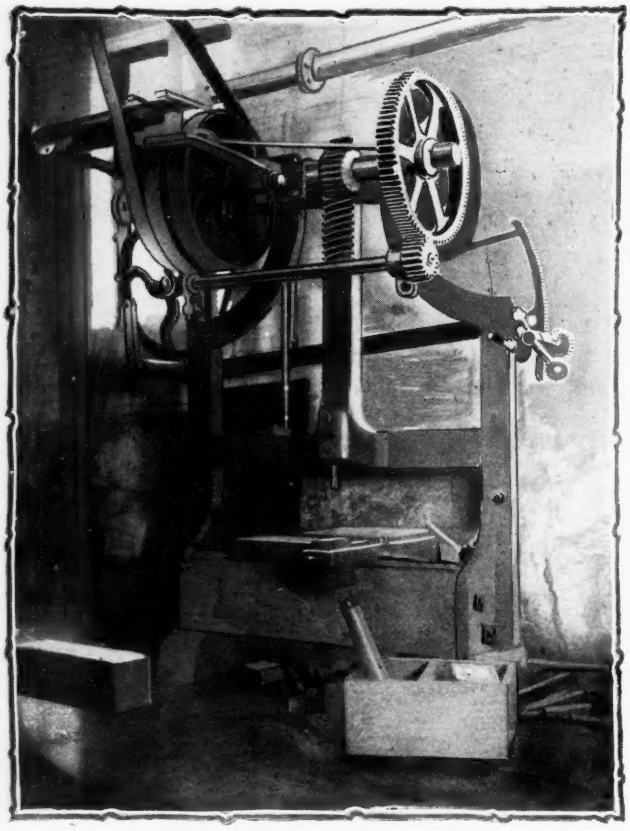

FIG. 10—AN OLD SLOTTER.

OBSERVATIONS IN AN OLD SHOP.—2.

Next to the boring mill shown last month is the drill press shown in Fig. 8, whose rectangular column gives a firm support for the table, and tends to resist any twisting action. The supporting arms under the table are not as deep as modern practice would suggest, but the machine as a whole is capable of good work. The column is large and rigid, and indicates a desire for solid tools at an early date. Power feed is provided for both table and drill spindle, in fact all movements can be controlled by power if desired. Many of these drills were sold in the late '40's and early '50's, and there are several distributed about this shop. In some instances two spindles were provided for a single machine, or it might be more correct to say that two drills had one table between them, the columns being independent except at the base. In one of these machines, evidently designed for spacing and drilling holes accurately on long beds for some textile machinery, every care had been taken to make it a perfect machine. The index or template was a long bar, drilled with the right distances between the holes, and the drill-heads moved until stopped by the dowel-pin in the right place.

On the same floor, all the heavy work being done in the basement, is the horizontal boring mill shown in Fig. 9, which is quite a curiosity in several ways. The uprights go to the ceiling, so they are well supported, and the racks shown control the vertical movement of the head. These being at each end of the head, tend to preserve the alignment while being raised or lowered, instead of being thrown out of line by having all the strain on one end. The vertical movement is controlled by the hand-wheel at the right, gearing through two pinions and a worm-wheel before reaching the pinion and rack. The head is counterbalanced by a weight on the other end of the chain shown at the center, aiding in handling the head. The spindle feed can be controlled by hand or power; the vertical rod at the left carries bevel gears which drive a shaft not clearly shown; this is belted to the small shaft above, where more bevel gears drive the worm and wheel at the left. By lifting out the worm the spindle is controlled by the hand-wheel, as will be readily seen. One rail of the track which runs at right angles to the boring spindle is shown, and in the distance the car which carries the work to be bored. It is not guaranteed that the track is at exactly right angles, but probably was nearly so when laid, near enough for the majority of the boring done, I presume.

Placing the work on this car, it was brought into position and blocked by various means, while the thrust of the boring-bar was taken by a large wooden brace, let down from the ceiling and braced at both top and bottom. The exact date of this tool was not given, but it was probably built in the neighborhood of 1840.

Near the old planer which was shown last month is another tool of interest, the slotter shown in Fig. 10. It need not be said that it is old, the design and everything connected with it indicates this; the redeeming feature, from the view of doing heavy work, lies in having the power directly in line with the resistance of the work. The speed of the counter is reduced three times by gearing, as will be seen. Of all the tools seen in this shop, this is the most unlike the modern tools, the rest containing for the most part modern ideas, even to some of the details of construction.

Ascending to the main floor, where the lighter work is done, the lathes shown in Figs. 11 and 12 are quickly noticed and examined. The chucking lathe is a solidly built machine, and has evidently done good work for years—and can yet for that matter. The tail stock is heavily built, has rack feed for the spindle and can be adjusted side ways and at any angle, as shown. The jaws shown in the center or steady rest present a handy way to hold the chucking drills, and are worked by a right and left screw for centering drills. It will be seen that adjustments are provided in about all directions, more liberally, in fact,

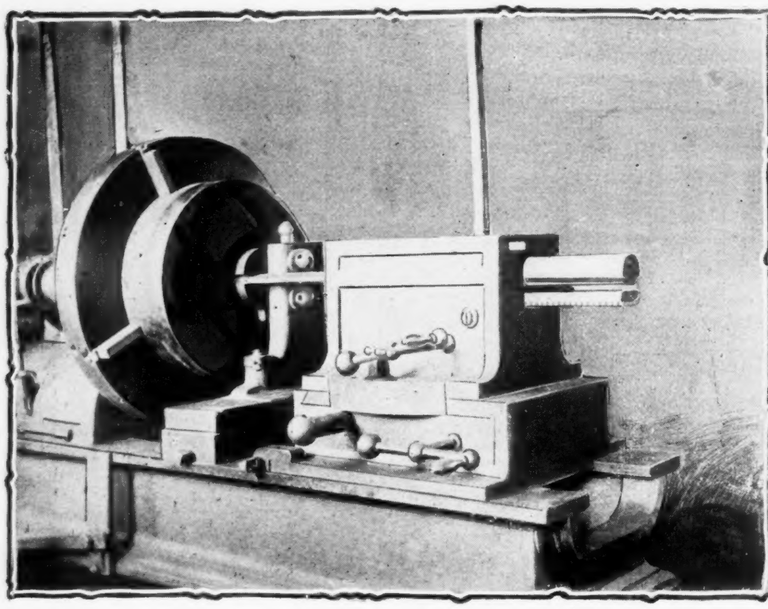

FIG. 11—CHUCKING LATHE.

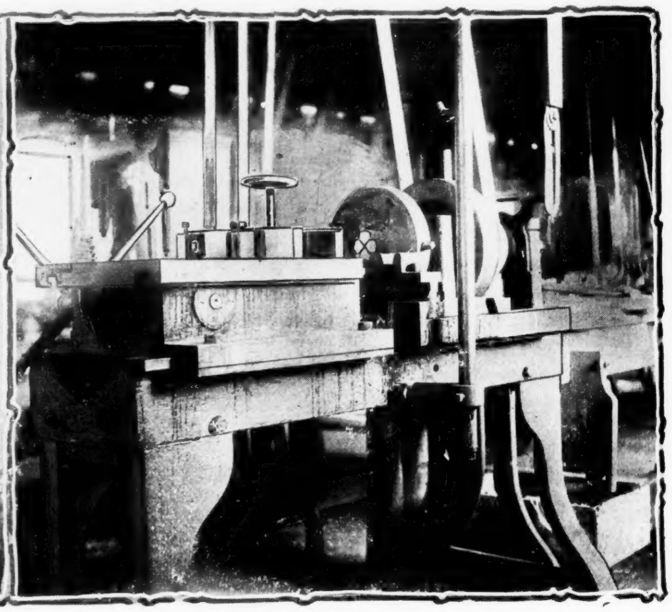

FIG. 12—TURRET LATHE.

than is deemed advisable at present. A smaller machine of the same type is also in use here.

The turret lathe shown in Fig. 12 is of later date, probably about 1860, and contains some familiar features, as well as some that are seldom seen. The turret is in the form of a six-arm pulley, the arms being rectangular in shape and of course having no rim. The tool-holes are in the end of these projections or arms, and set screws are provided for holding the tools. The indexing pin goes through the turret and into the slide, and consists of a rod, tapered on the point, with a small hand-wheel for ease in handling. There is a cutting-off slide close to the chuck, as shown, and this could not be moved along the bed as in the

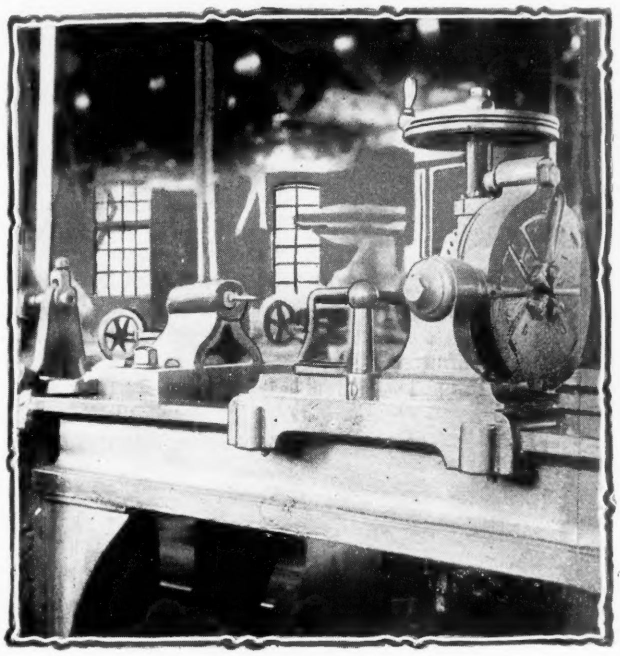

FIG. 13—OBSERVATIONS IN AN OLD SHOP.

later machines, the supposition evidently being that all cutting off would be done next to the chuck. The one special feature of this machine is the turret slide as seen at the back, this form of slide keeping all dirt from the sliding surfaces. While the writer would not advise exactly this form of slide, as the comparatively small ┏ shaped pieces are not desirable, the feature of having the carriage slide come over the under portion, or ways, is a very desirable one, and one which was too long neglected by some builders, in fact has not yet been universally adopted. In order to make this completely effective, the slide must be as long as the body plus the travel, to prevent the ways from ever being uncovered during operation. With the other form of construction the accumulation of dirt and chips in the slides is a serious matter.

The bolt cutter shown in Fig. 13 is rather interesting, as the die is opened and closed by the hand-wheel shown above. Different chasers can be inserted for various sizes and threads of bolts. The die is mounted on the carriage of an ordinary lathe which has done service for many years. It was a noticeable feature of the lathes made by this firm (Silver & Gay Co., North Chelmsford, Mass.) that ever since their adoption of the screw feed they have placed this inside the bed, out of the way of chips and where it takes the most of the work, *i. e.*, nearly under the cutting tool. The rack for feeding carriage, when not cutting screws, was also placed inside of bed, for the same reasons that placed the screw there.

Among the records of tools shipped I found that from March 22 1851, to May 3, 1853, the New York and Erie R. R. bought geared drills, bolt-cutters, pattern-makers' lathes (double-headed), and two engine lathes taking 11 feet between centers. A trip-hammer, other engine lathes, back-geared and with screw feed, from 15 to 20 feet between centers, and as high as 54 inches swing. These went to the shops at Dunkirk, N. Y.

Another planer, but of considerably later date, is seen in Fig. 14. The paneled sides of the housing indicates the old design, probably about 1845 to 1850. This has been added to in the shape of a long "clapper" carrying four tool-posts for grooving rolls, four at a time, and the long arm at side shows how the idea of lsat raising the tool off the work on the back stroke, mentioned month, was adhered to in later machines. In Fig. 16 is seen an old graduated or dial wheel, probably six feet in diameter, with the ring or rim drilled with hundreds of small holes, as will be seen on close examination. These divide it into almost any number of parts that can be asked for, the small chalked circles near the inner edge probably showing the ones last used. This is mounted in the heavy wooden frame shown and was found on the top floor of the old shop, where the light was decidedly uneven, or "streaky," as shown by the photograph. Rumor has it that this was the original or master plate for about all the finer graduated discs or indexes in New England, and that the one first used by Brown & Sharpe originated here.

This is, however, only a rumor, as Mr. Lucien Sharpe informs us that in their first gear cutting machines, constructed between 1850 and 1852, the copper circle on the edge was divided by a machine belonging to the U. S. Government Coast Survey at Washington, D. C. Until very recently this gear cutter was said to be the most accurate machine in use in any machine shop in this country, and has been used largely for drilling index plates and other accurate work.

* * *

ANOTHER ROTARY ENGINE.

SAMUEL WEBBER.

I was very much amused with the "Notes from Notown," by "Ichabod Podunk," in your January number, and they impel me to send you some experiences of my own with a rotary engine last month, which, if they do not afford any very valuable information to your readers may, at least, serve as a sort of "finger-post" to warn the inexperienced from putting too much faith in new and "revolutionary" improvements in the steam engine.

I use the last adjective advisedly, since all attempts, so far, to utilize steam by a revolving piston have proved a failure, and the new steam turbine, which is as old as the days of "Hero Alexandria," offers the most practical solution yet of the problem of getting power from steam by a rotary motion.

To come to the point, I was invited last month to go to a large town in the interior and examine and report upon a new rotary engine by some capitalists who had been urged to invest money in it. For obvious reasons, I do not mention either names or places, but after obtaining from the parties who called on me a copy of the patent and the claims set forth in it, I attended to my mission. I found a compact little engine, with a cylinder 18 inches diameter inside, and 6 inches wide, or long, as you choose to call it. Through this cylinder ran a hollow shaft, 6 inches diameter with a projecting vane or piston, which had a surface of 6

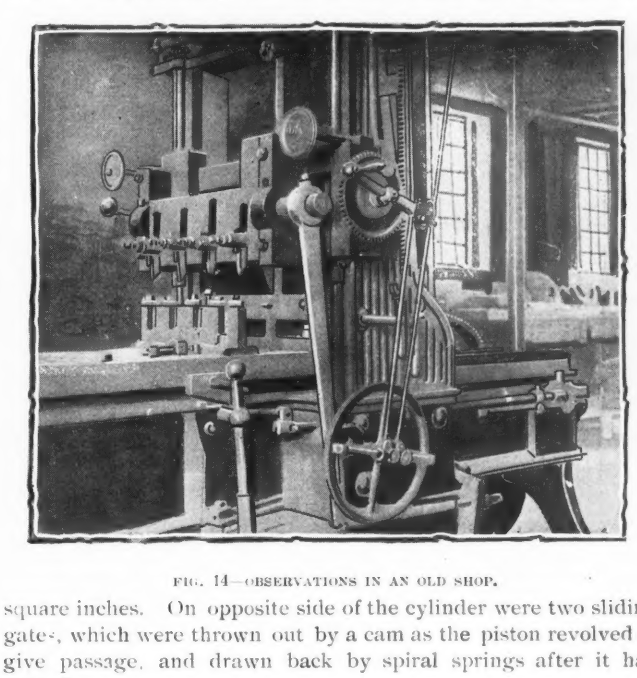

FIG. 14—OBSERVATIONS IN AN OLD SHOP.

square inches. On opposite side of the cylinder were two sliding gates, which were thrown out by a cam as the piston revolved to give passage, and drawn back by spiral springs after it had passed.

The steam was admitted to the interior of the shaft by ports, or a port, which received it from an external collar, into which the steam pipe led, and delivered it into the cylinder behind the vane.

This port admitted steam during one-quarter of a revolution, then closed and allowed the steam to expand during another quarter; then an exhaust port on the opposite side of the shaft opened and discharged the steam through the other end.

As the inventor had designed his engine to be run either way, both the inlet and outlet openings in the two collars at either end were on top, so the condensed water had all to be lifted or blown out, thus causing a large amount of back pressure. The inventor had previously called in the city engineer from his legitimate work on the streets and sewers—a very bright young man—who had got up a Prony-brake to test the power delivered by the engine, and put a cam on the shaft to give the necessary reciprocating motion to operate a Crosby indicator, and had taken a set of cards from different points, while obtaining the power delivered by the brake.

These cards were rather curious affairs, but showed that the steam pressure actually acting on the piston was about 10 per cent. greater than the value of it, as delivered at the brake. They also showed, however, that the exhaust port opened while the steam was nearly at half-pressure, from which point it fell at once, rapidly, seeming to be practically used up, in the third quarter of the revolution, from which point the engine seemed to be carried on by the fly-wheel. I at once noticed this enormous loss of steam and decided on a different mode of operation.

Retaining the friction pulley and brake, which I found, I added another arm to the brake on the opposite side, to which I attached a "hydraulic regulator," or piston working in a "dash-pot" of water, reversed the brakes, so as to lift a positive weight, instead of bearing down on a platform scale, procured a set of weights from the "City Sealer," and was ready to determine the power delivered.

I saw, however, that the real point, the quantity of steam consumed, had not been touched; so after a day's search of all the store and repair shops in town, I found a small, second-hand vertical tubular boiler, 3 feet long and 2 feet diameter, which had formed part of a house-heating apparatus. This I set up outside the building and inside of a big sugar hogshead, blocking it up from the bottom about 6 inches, led the exhaust pipe from the

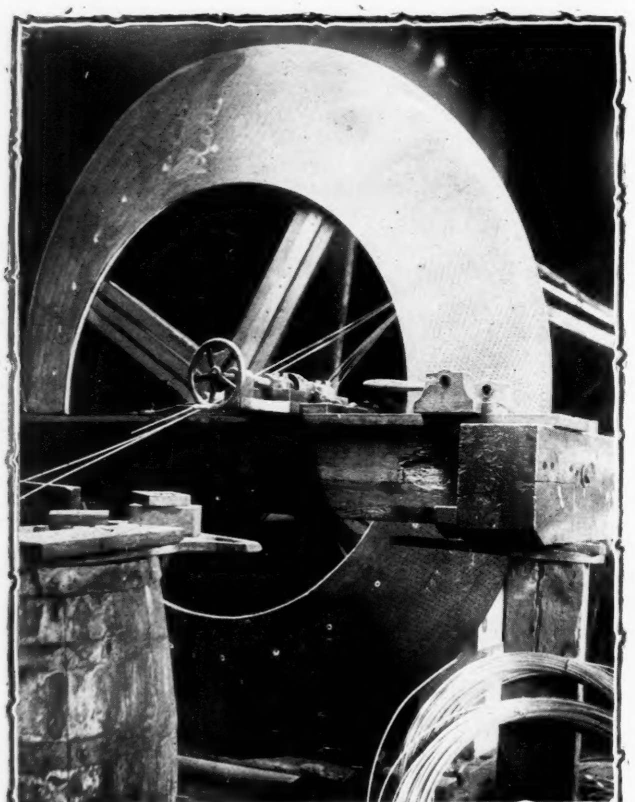

FIG. 14.—OBSERVATIONS IN AN OLD SHOP.—SEE PAGE 198.

engine into it near the top, and carried a pipe from the bottom back in the building into a tank placed on a platform scale, so that the condensed water could be all caught and weighed.

To condense it, we brought a hose from a convenient hydrant, and poured a stream of water into the top of the boiler, which had a 3 inch flange all around it, and this water, flowing down through the fire tubes, came up around the outside and overflowed through a gap cut in the rim of the hogshead. This answered my purpose perfectly, and gave me a steady flow of condensed water into the tank, which was weighed every five minutes, while we were using the brake. I will not weary your readers with details, but give a summary of the results condensed from several series of trials with different loads.

The brake arm was 5.252 feet long, or the radius of a 33 foot circle, the friction pulley 30 inches diameter and 3 inches face. Beginning with a light load, we increased it as far as the strength of the friction pulley would allow, and as the last results were practically uniform, stopped when we got 10¾ HP. from the engine.

Tabulated they read as follows:

Lbs. in Scale.	R. P. M.	H. P.	Steam Pressure.	Back Pressure	Lbs. Water per hour.	Lbs. Water per Brake H. P.	Lbs. Water per H. P.
1 50	73.2	3.68	75.	5	512	140.	126.
2 50	72.5	3.63	65.	5	500	137.5	123.75
3 75	70.6	5.295	67.5	5	580	109.5	98.55
4 75	87.65	6.57	72.5	6	565	86.	77.4
5 (steam throttled off) 75	72.5	5.437	68.	6	572	105.	94.5
6 100	83.95	8.40	69	6	744	88.6	79.74
7 100	84.5	8.45	64.	8	702	83.	74.70
8 125	82.5	10.28	71.5	10	870	84.63	76.17

In trials 1, 2, 3 and 5, the inventor throttled off part of the steam, until I protested, and trials 4, 6, 7 and 8 were made with a full head of steam, showing much better results.

The steam was taken from the boilers of a large factory, across a narrow alley-way, and was quite irregular in pressure, but the pipe was thoroughly wrapped with old bagging the whole way to the engine, and the weather was quite mild and thawing during the trials.

In order to render my results more intelligible to the parties who employed me, I made a comparison of them, with the quantities of water or steam, shown by various tests as used by other engines, adding another column to show the fuel required per HP., at an average estimate of 9 pounds of water evaporated from 60 degrees Fah. by 1 pound of coal, as follows:

	Water per H. P.	Coal per H. P.
	Lbs.	Lbs.
Rotary engine, average of tests Nos. 4, 6, 7 and 8........	77.	8.54
Old slide valve single engine..........	45.	5.
Prof, Goss' test of Laval steam turbine..........	43.	4.78
Prof. Carpenter's Sibley College test, Corliss single......	24.	2.67
" " " " " " compound..	16.5	1.83
My own test, at Trenton, Allis triple compound..........	13.41	1.42

I reduce all these 1 HP. at 10 per cent. less than for brake HP.

It is but fair to say that we had to lift all the exhaust 5 feet to get it into the condenser, and I endeavored to console the disappointed inventor by telling him that if he made his exhaust discharge downward, to relieve the excessive back pressure, jacketed his cylinder, made his feed-port open quicker, and moved his gates both in and out by a proper cam, thus avoiding the resistance of the heavy spiral springs, which drew them in, he might probably save 25 per cent.; and as his engine was very compact, worked very smoothly and required no foundation, he might make it useful on a portable boiler, for saw-mills, or threshing machines, where the sawdust and straw supplied fuel without expense, but that I could not in conscience recommend it where fuel had to be purchased for it.

I felt sorry for him, for he was an ingenious fellow, who, having got up a good friction coupling, which he sold for a fair price and which the purchasers re-sold for ten times what they paid him, thought it advisable to turn his profits and his wits to the improvement of the steam engine, with the result as shown.

* * *

THE FITCHBURG MACHINE WORKS, Fitchburg, Mass., are very busy on heavy drill presses and lathes, being obliged to run several nights a week to keep up with orders. When this is found necessary the men are given a fifteen minute lunch, prepared by a caterer, with their pay going on just the same. Recently Mr. Chapman, the genial manager, extended the lunch time another fifteen minutes and passed around cigars and pipes to while away the extra time. They have built a very complete pattern-makers' lathe for the Herreshoffs, at Bristol, R. I., which is the most convenient and rigid lathe of the kind we have seen. It has a gap, made by running the top of bed back, and has a complete lathe carriage which is mounted on substantial ways the same as an engine lathe. For large turning, the back end of lathe spindle is threaded for face-plate, as is usual, and is provided with a cap to protect the thread of spindle when face-plate is not in use.

HELICAL GEARING.

CISNARF.

Very little information can be found in text books on this subject; it is lightly treated, a few crude cuts given; the rest being left for experience to teach. It appears that writers are unable to get hold of anything but theoretical information on the subject; why, it is hard to explain, for this style of gearing and its modifications are in universal use, but generally in connection with a "rolling" process.

From the first, straight-faced spur gears have given endless trouble when used on delicate work (when I say "delicate," I do not mean always fine, light work, but that which needs careful working to produce good results), the uneven rotation produced, especially when the teeth were a little worn, marked the strips of product periodically. When small gears were used, such as "roll pinions," the small number of teeth made a very short arc of contact between the teeth, and the power transmitted at great angles; the resultant motion was uneven and unsatisfactory.

A partial remedy for this was the scheme of "multiple-faced" gears; one of these is shown in Fig. 1; it is an equivalent of several narrow-faced gears, joined together in such a position that the teeth of one section are slightly ahead of the one adjacent. The result obtained is, that at all times a pair of teeth is at or near the point of maximum efficiency, the line of common centers. When a tooth is at the point A, and about to end its contact with its partner on the other gear, a pair at C is in its best position, accomplishing the desired result, a continuous motion. A few objections are raised against this system: the teeth lack continuity in regard to face, and unless the "shroudings" are used between the different faces, the moulding is bad, especially if the number of faces be small. Where the "shroudings" are used, the effective face is greatly diminished, leaving a very narrow tooth liable to get the whole stress. It is not an easy matter to get the teeth on two patterns exactly alike, in this "advancement" of face, which is necessary, if the gears are to run satisfactorily. It is not easy for the moulder, when there are several faces, to avoid distorting the mould; even a little is enough to ruin the casting. The teeth cannot be cut in the casting of such a gear, except by cutting the sections separately, then bolting them together, a job that our best shops would shun, from a commercial point of view, anyway.

A natural development of the staggered teeth was some method of providing for continuous faces and still preserve the advantages of the advanced faces; this was found by making simply a "slanting" face. A straight line D, as in Fig. 2, laid on a flat sheet, then wrapped around a cylinder, gives the "spiral" or helical face; if a helix is a spiral, it is proper to call it thus, but I understand that a spiral is a plane figure. Such a slant as given to this line, if applied to a gear face, would give an immense end thrust when running; so, to avoid this, these helices are always used in pairs, slanting in opposite directions (Fig 3). Assuming the pitch, number and shape of teeth to be settled, also the face, we have enough data to determine the slant of the helix. The first point to consider is the nature of the work to be done. If comparatively light, and continuous running is the object in view, the helical pitch may be made equal to the tooth pitch, maybe more if the face is large; but if the work is heavy, good results have been obtained by making it about three quarters of the pitch, but in no case should the angle (Fig. 2) exceed thirty degrees. From this it is apparent that the face chosen for the gear has considerable influence on the helical pitch. Too large an angle produces "wedging," when running, and could be increased to such a point that the teeth would jam and gears refuse to rotate.

The working of a pair of these gears can be examined in Fig. 3; as the tooth shown on the line of centers is supposed to be a section at the center line of the face, it can be easily seen that as it rolls toward the point of breaking contact, the outer portions of the next tooth are taking the position that this one has just left, giving, at all times, a pair of teeth at the line of common centers. The gears work well, are not very difficult to make, except in moulding, for the pattern is twisted in drawing out of the sand, and a careless workman is liable to injure the mould.

In laying out such a gear on paper, the shape, pitch and sizes of teeth are determined exactly as with a straight-faced gear, the end and side clearances being in no way affected by the helix; the end view, as in the figure, being available for a straight face also. It is commercially impossible (reckoning cost as a possibility) to work the teeth on the pattern by hand; it is pretty certain that they cannot in any case be cut by hand. The cutter to be used on a machine should be laid out in the drawing-room, and not left for the shopmen to do. The pattern is generally in two pieces (not counting the end flanges), and is divided at the center line, each half of it being worked separately; the cutter is used as shown at R, revolving perpendicularly to the center line of the shaft, the gear being revolved the amount of helical pitch. In many cases of hurried work, also in thoughtless work, the shape and size of the cutter has been made to correspond with outlines as shown on the end view, simply that the space to be cut is the space shown there; a glance at the figure will show that the distances in the direction of the line F, perpendicular to the helices, are the determining measurements for the cutter. The exact outline of this is obtained as in Fig. 4, two teeth are drawn showing the end view of the space to be cut, as denoted in Fig. 3; the line O H above shows the pitch of the helix for half the face O L. Numerous short lines are drawn along the tooth outline, the intersections being projected to the line O L. Taking O as a center, small arcs are drawn from these projected intersections on O L to the "helix" O H: the intersections of the circular arcs are projected back to the lines cutting the tooth curve, care being taken to intersect with the same line from which the first projection was made. The points, when joined by a carefully drawn line, will give the shape of the curve, referred to the direction F, which is the outline of the cutter. There are other methods of determining this shape, but the one given is as short as any, and is recommended for its simplicity, and also for its possible use in many other cases requiring a similar process.

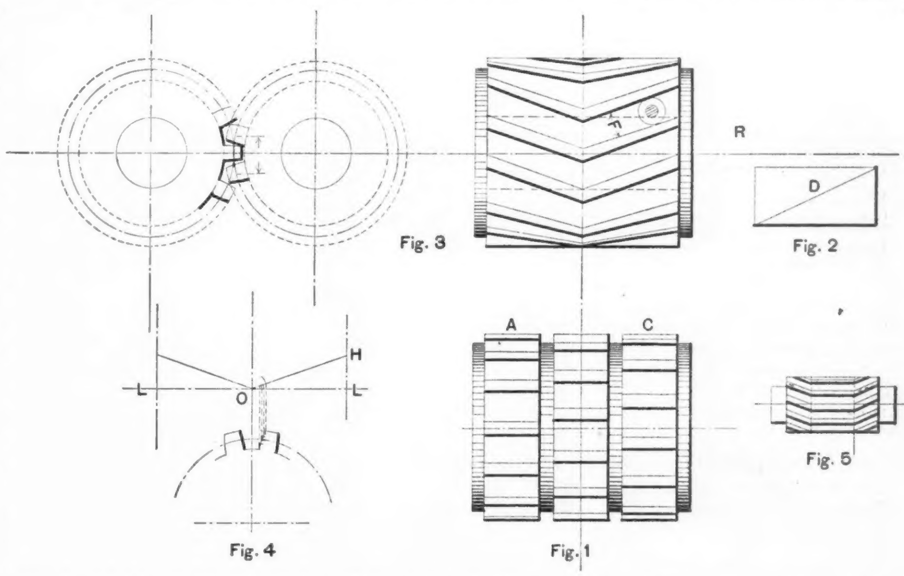

Fig. 3 Fig. 2 Fig. 4 Fig. 1 Fig. 5

Soft wood teeth, on a pattern cut this way, are not satisfactory; the wood tears, splits and produces a ragged surface, which, when smoothed down by hand, destroys the shape of the tooth; using a soft wood center with roughed-out hardwood teeth fastened to the pattern in any of the good modern methods, the machine cutting will be done easily, quickly and result in a good job.

The machine moulding of helical teeth is a very difficult task, and is practiced only where gears of large diameter are required, which is not very often. In England there is a tendency to use these faces on very large gears, but in this country we have few, if any, of such ponderous combinations. These remarks deal with gears running on parallel shafts only, no reference being made to the fancy combinations sometimes used as spur gears on perpendicular shafts. A combination of spur and helical faces appears in a patented gear, and its merits and demerits (it has both) cannot be discussed here. The outline is, roughly, a straight gear in the middle, with helical face, pitching in opposite directions on each side (Fig, 5).

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WE solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense.

ALL copy must reach us by the 10th of the month preceding publication.

MARCH, 1896.

WHILE it is gratifying to find an increasing demand for skilled mechanics, it is disappointing to learn that considerable difficulty is being experienced in securing the men to meet the demand. We know of more than one shop where good men are at a premium and where almost anyone is hired in the hopes of getting a few skilled mechanics and draftsmen, only to find that a very small proportion are of the class wanted. It is not a question of wages nor of undesirable location, for these shops do not want cheap men, knowing that a high priced man is usually more profitable than a cheaper one.

If it be true that there is a scarcity of skilled mechanics for regular high grade machine shop work, it does not necessarily prove that the men are less intelligent or even less skilled, but it may be that their skill has been confined to one particular line; and when it comes to regular machine work, they are not able to do justice to themselves nor their employers. While this extreme subdivision of labor is necessary for the greatest economy in manufacturing, the fact that it limits the supply of desirable men for regular machine work indicates that it is not always advantageous to the employer, and is often very injurious to the men, as it limits their range of work and with it their chances of obtaining other employment.

This adds another to the list of problems in modern manfacturing; and as with the others, it shows that every man is dependent on his neighbor and that both are co-workers in the fullest sense, and that one party cannot be injuriously affected without eventually injuring the other. Both sides of the question must be considered.

* * *

SELF DELUSION.

We are very apt to blame inventors of devices which are supposed to perform improbable or impossible feats, as endeavoring to delude others in order to enrich themselves. While this is sometimes the fact, it is not always true; for in the majority of such cases the inventors are as much deluded as any one—often more so. And as a self-deluded man is the hardest of all to convince of error, his friends who remain sane must either humor him or incur his lasting displeasure, to say nothing of being called a doubting Thomas and other names more forcible than elegant. The conservative man is often behind in the adoption of new devices, according to the amount of proof needed to convince him of their merits.

The inventor often fails to find defects, or imagines them of no consequence, as in his case a little attention overcomes them, while in everyday use this attention, however small, is apt to be lacking. When it comes to tests of the new invention, the pitfalls are many and deep, and the unwary inventor, not critical when it comes to his own device, falls a ready victim to tests which are apparently all right, but which may give results that are absurd to an outsider. For example, boiler tests, by inventors, are sometimes said to give unheard of evaporations. Small, simple engines with some new valve, give economies beyond the best multiple expansion engines of large size; and tools, hardened in a mysterious compound, perform wonderful feats of cutting, as, for example, a cold chisel first used as a chisel and then as a razor, and many other impossible feats. And yet many times the inventor is innocent of intention to deceive—he simply deceives himself and as many others as he can.

When we find a device, even of our own, giving unheard of results, it is wise to look closely into details of the tests, and to have others do the same, who are honest enough to point out defects and not pat our backs for the fee they are to get. Advances are not usually made in sudden spurts and bounds, but by steps, slow and often painful (to those who have to foot the bills); and we will save time, money and reputation by being as skeptical of our own device as of another's, or by hiring a skeptic to find the weak spots.

PRACTICAL TALKS ON MECHANICAL DRAWING.—(4).

Louis Rouillion.

SHEET XII.

DEVELOPMENT OF A RIGHT ELBOW.

Draw the top and front views of a right elbow, to the dimensions given in Fig. 17. The development of the lower part of the elbow is obtained as shown in Sheet X. The development of the L part is obtained in the same manner, and, for the sake of the

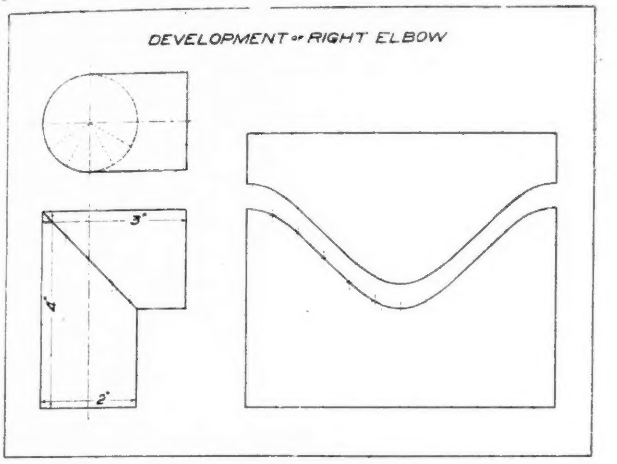


FIG. 17.

symmetrical appearance of the sheet, is represented in the drawing above the first pattern. A good general rule to observe in making the cut is to make it on that part of the pattern that will require the least seam. The reason for this is obvious.

SHEET XIII.

DEVELOPMENT OF A FIVE-PIECE ELBOW.

In Fig. 18 is shown the front and top views of a five-piece elbow, together with its development. The top view is not necessary in order to obtain the development, and is given only as an additional exercise in drawing. If, however, the top view were not given it would be necessary to draw a semi-circle on the base line as diameter, in order that the required division points might be obtained.

First draw the front view of a 2-inch cylinder of indefinite height. At 1¼ inches above the base draw a line parallel to the base and extend it to the right. The distance that this line is extended depends upon the sharpness with which it is required that the bend should be made; the shorter the extension the sharper the bend. In this instance the line is extended to the right a distance equal to the radius of the cylinder, making a line 3 inches in length. Take this distance in the compasses and

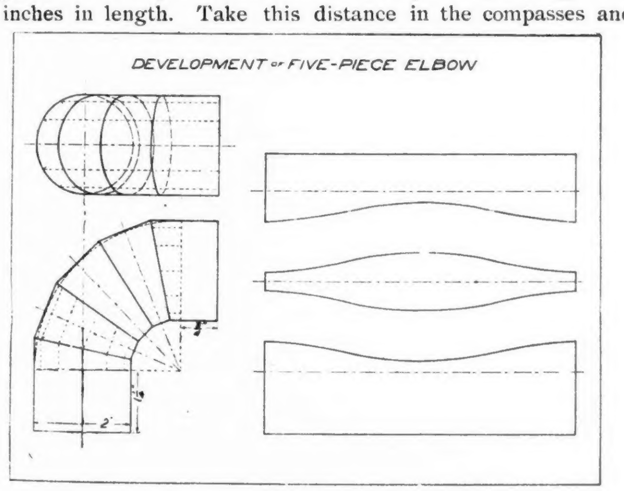


FIG. 18.

with the right-hand end of the line as a center describe a quadrant in the direction of the bend of the elbow. Also at the point taken as a center, erect a perpendicular to meet the end of the quadrant. Divide the right angle thus formed into four equal angles; that is, one less than the number of parts composing the elbow. This may be done by first dividing the angle into two equal angles by aid of the 45 degree triangle, and then by trial with the dividers finding upon the arc already drawn the center points of these angles. The sides of the angles serve as center lines of the various parts of the elbow. The bisectors of each of these angles are the joints of the elbow. The lowest one of these joints crossing the indefinite height of the cylinder as first drawn completes the lowest part of the elbow. To obtain the second part, draw lines from the extremeties of the top of the first joint at right angles to the center line of the second part until cut by the second joint. The remaining parts are obtained by the same method.

The development of the lowest part is obtained as in the previous sheet. The three center parts are identical; therefore it will only be necessary to make one pattern. Draw a horizontal line to represent the center line of the front view. From the pattern of the lowest part already obtained, extend the vertical end lines upwards and on these lines cut off, on either side of the center line, the throat measurement as shown in the front view. The greatest width of each part is obviously at the back, and is shown in the center of the pattern. All intermediate distances between these two extremes are found from the front view. In Sheet X. all the elements of the front view and development are drawn in full. In Fig. 18 these lines are not all shown, but should be drawn in pencil by the student. They are shown, however, on the next to the lowest part of the elbow. The corresponding elements should be drawn on the lay-out of the pattern and the distances taken above and below the center lines, as obtained from the front view.

SHEET XIV.

DEVELOPMENT OF THREE INTERSECTING PIPES.

Draw a cylinder 4 inches high and 2 inches in diameter. At the middle of one side intersect it with a cylinder of 1½ inches diameter, and cut off ¾ inch. On the opposite side intersect at 60 degrees with a cylinder of 1½ inches diameter. Let the lower edge of the inclined cylinder intersect the larger cylinder at ½

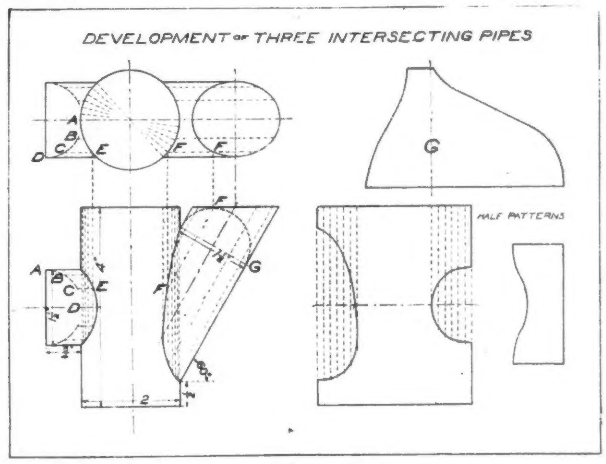


FIG. 19.

inch from its base. Draw front and top views and half-patterns of each pipe.

First draw the front and top views of the three pipes to the dimensions given, disregarding their intersections. The method of finding the curve on the front view made by the intersection of the two pipes at right angles will first be considered. Divide the small cylinder into a number of equal parts, by describing a semi-circle on its base and on the semi-circle stepping-off the required divisions. This semi-circle answers the purpose of an end view. As the axes of the two cylinders intersect at right angles, each quarter of the curve is like each of the other quarters, and it will therefore only be necessary to show how a quarter of the curve is obtained. The points of division taken are shown in the two views at A, B, C and D. These letters represent similar lines in each view. Through these points draw elements of the small cylinder parallel to its axis. From where these elements intersect the top view of the large cylinder project lines down to the front view, and where these projecting lines intertsect the corresponding elements in the front view will be points on the required curve. This method is shown in the drawing in the case of the point C. The point C is one of the equal divisions of the semi-circle representing a partial end view of the small cylinder. Through it the line C E is drawn as an element of the small cylinder parallel to its axis. This element intersects the top view of the large cylinder at point E. From this point the vertical projecting line E E is drawn, and where it intersects the line C E of the front view is a point on the curve. In this manner find a number of points and join them by a smooth curve.

The curve formed by the intersection of the large cylinder and the smaller one inclined to it is found in a similar manner. As the axes do not intersect at right angles, only the halves of the curves are similar, and it will therefore be necessary to find one half of the curve. In the top view use the elements already found, extending them to the right. At some point on the axis of the inclined cylinder describe a semi-circle of 1½ inches diameter, the diameter to be drawn at right angles to the axis. Divide this semi-circle into the same number of parts that the semi-circle in the top view is divided into. The points on the curve formed by the intersection of the two cylinders are found in the manner already described. One such point is shown at F, together with the method for obtaining it.

The top view of the inclined cylinder shows an ellipse. Points on the ellipse may be found by the intersection of any element of the top view with the projection of a similar element of the front view. Such an intersection is shown at the point F on the ellipse. This ellipse plays no part in obtaining the pattern, and therefore would not be required to be drawn, if the laying out of the pattern is the only thing desired.

Having finished the two views, together with the intersections, it is now required to lay out the patterns. It is obvious that each pattern may be cut into two similar halves. It will therefore be necessary to lay out only one-half of each pattern.

Begin with the laying out of the half-pattern of the large cylinder. Extend the top and bottom lines in the front view indefinitely to the right and cut off by vertical lines an area equal to one-half the surface of the cylinder. The method for doing this was given in Sheet X. In the top view of the large cylinder observe what portion of the circle is embraced by the intersecting cylinders and divide this portion of the circle into a number of equal parts. Take one of the parts in the dividers and step off an equal number on the pattern, and through the points draw vertical lines. From the points of division on the circle drop vertical lines across the front view of the cylinder. The vertical lines on the cylinder—or elements, as they are customarily called—correspond line for line with the vertical lines on the pattern. It is only necessary then to project horizontal lines from the intersection of the elements with the curve previously found over to the corresponding elements on the pattern. A series of points will thus be found which when joined by a smooth curve will give the desired cut in the pattern. The principle is similar to that given in the previous sheet.

The half-pattern for the inclined pipe is readily found by taking any line, as G, for a base line, and laying off the distances above and below this line on the various elements. By observing the part of the inclined cylinder above the line G, it will be seen that it is simply a cylinder with a slant cut. We have already had a similar problem in Sheet X. The part below the line G is obtained in a like manner. The same process is applied in obtaining the half-pattern of the small projecting pipe at the left.

SHEET XV.

DEVELOPMENT OF TAPERING SECTION OF PIPE.,

The method used for obtaining the development of all warped or tapering surfaces other than sections of a cone is that of "triangulation." Briefly stated, the method consists in finding the true lengths of a series of elements on the surface, and then locating the correct positions of these elements on the pattern. As the true lengths of the elements are found by the aid of triangles, the process is termed one of "triangulation." The principal involved is simple, easily acquired, and a most useful one, as a large number of problems may be solved by its aid.

The example given in Fig. 20 is that of a tapering section between two circular pipes; the larger one 2½ inches in diameter, and the smaller 1½ inches in diameter. The distance between the ends of the pipes is 2 inches, and their axes are parallel and 1½ inches apart. Draw a top and front view to these dimensions. First draw the three center lines; then draw the two circles in the top view and connect them by tangent lines. For the front view, draw the pipes of indefinite length, and connect the extremities of their bases by lines.

Divide one-half of the small circle into any number of equal parts, *a*, *b*, *c*, *d*, *e*, *f*, *g*, and the corresponding half of the large circle into a like number of parts, A, B, C, D, E, F, G. Connect *a*, A; *b*, B; *c*, C, etc., by straight lines. These lines are elements of the surface. Find their projections in the front view by projecting *a*, *b*, *c*, etc., to the line *a g*; A, B, C, etc., to the line A G, and connecting *a*, A; *b*, B; *c*, C, etc., in the front view, by straight lines. In the top view connect the alternate extremeties of the elements by the lines *b* A, *c* B, *d* C, *e* D, *f* E, and *g* F. Draw the projections of these lines in the front view. These are designated by lines lettered similarly to those of the top view. These last lines form a series of "auxiliary" elements, the purpose of which will appear when laying out the development. It will be seen that of all the elements drawn in the front view, *a* A and *g* G alone show true lengths. The next step then is to find the true lengths of the other elements. Let us first find the true length of the line *b* B in the front view. Draw a right angle having the altitude of the taper for one side, and the line *b* B in the top view for the other side. The hypotenuse of third side of the right triangle, will be the true length of the line *b* B. Such a triangle is shown in Fig. 20, at the extreme right, as the smallest in the nest of triangles. As the distance between the two pipes is constant, one side of all the triangles will be the same; in this case 2 inches. To find the true length of *c* C in the front view, proceed in the same manner as in finding the true length of *b* B. For the base of the triangle lay off a distance equal to *c* C in the top view, take the altitude of the taper for the other side of the right angle, and then draw the hypotenuse, which is the true length of the line *c* C. In like manner obtain the true lengths of *d* D, *e* E, and *f* F.

It is next necessary to find the true lengths of the auxiliary elements *b* A, *c* B, *d* C, *e* D, *f* E, and *g* F. These are shown by the nest of triangles in the center of Fig. 20. The letters at the top of the triangles are given in the order in which the lines are drawn. To find the true length of *b* A, draw a right angle having for one side the altitude of the taper and for the other the line *b* A

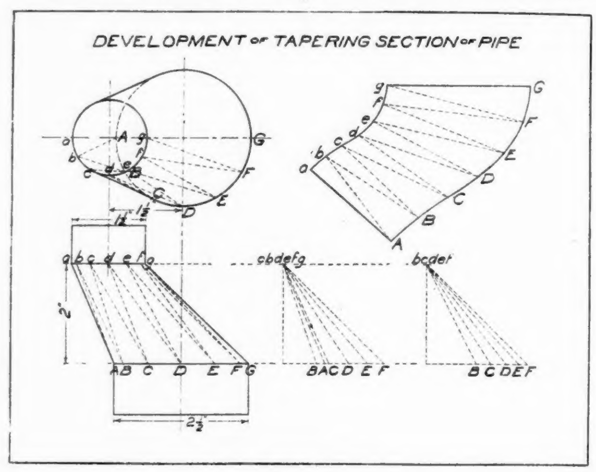


FIG. 20.

in the top view. The hypotenuse of the right-angled triangle is the true length of *b* A. In a like manner find the true lengths of *c* B, *d* C, *e* D, *f* E, and *g* F.

We now have all the data required for laying out the pattern. Draw a line equal to *g* G of the front view. Such a line is shown as *g* G at the upper right hand corner of Fig. 20. During the remainder of the explanation, all letters refer to those given on the pattern, unless otherwise stated. With G as center, and radius equal to G F in the top view, describe an arc. With *g* as center and the true length of the auxiliary element *g* F as radius, describe an arc cutting the first arc at F. With *g* as center and radius equal to *g f* in the top view, describe an arc. With F as center and radius equal to the true length of the element *f* F, describe an arc cutting the former one at *f*. The correct position of the element *f* F, with relation to the element *g* G, is thus obtained, and the points *g*, *f*, G, F, are points on the curve. To continue the pattern the same process is pursued. With F as center and radius equal to F E in the top view, describe an arc. With *f* as center and radius equal to the true length of the auxiliary element *f* E, describe an arc cutting the other arc at E.

With *f* as center and radius equal to *f e* in the top view, describe an arc. With E as center and radius equal to the true length of the element *e* E, describe an arc cutting the other arc at *e*. The correct position on the pattern of the element *e* E is thus determined. The process is continued until the position of the element *a* A is found. The points *a*, *b*, *c*, *d*, *e*, *f*, and *g* are joined by a smooth curve, as are also the points A, B, C, D, E, F, and G. This gives a half-pattern. The other half is exactly like it, and may be joined either to the line *a* A, or to the line *g* G.

Similar letters refer to similar lines and points on each of the

drawings on this sheet. Any line may thus be easily followed throughout its entire career.

EXERCISES.

EXERCISE 12.—DEVELOPMENT OF AN ELLIPTICAL RIGHT ELBOW.

Substitute for the 2-inch circular pipe of Sheet XII., an elliptical pipe having a major axis of 2¼ inches and a minor axis of 1⅞ inches.

EXERCISE 13.—DEVELOPMENT OF AN ELLIPTICAL FOUR-PIECE ELBOW.

Substitute for the 2-inch circular pipe of Sheet XIII., an elliptical pipe having a major axis of 2¼ inches and a minor axis of 1⅞ inches, and let the elbow be composed of four pieces instead of five.

EXERCISE 14.—DEVELOPMENT OF THREE INTERSECTING PIPES.

In Sheet XIV. substitute for the large circular pipe an elliptical one having a major axis of 2½ inches and a minor axis of 2 inches. Let the dimensions and positions of the two smaller pipes remain the same.

EXERCISE 15.—DEVELOPMENT OF TAPERING SECTION OF PIPE.

In Sheet XV. substitute for the smaller circular pipe an elliptical pipe having a major axis of 2 inches and a minor axis of 1½ inches, and let the remaining conditions be the same as in Sheet XV.

These exercises aim to be only sufficiently different from the regular sheets to obviate copying. No new principles enter into them, and they may be worked out by the explanation given in the regular sheets having corresponding numbers. As a rule, the difference between the exercise sheet and the regular sheet consists in substituting an elliptical cylinder for a circular one. This is sufficient to change the contour of the curves. The ellipse in the top view is divided into any number of equal parts as in the case of the circle, and to lay out the pattern one of the divisions is taken in the dividers and stepped off as many times as there are divisions in tho top view.

* * *

HERE AND THERE.

CLEARANCE AND COMPRESSION.

MR. EDITOR:

I've been trying to get up to knowing just a little something about the effect of clearance and compression on the cylinder of a steam engine, but don't seem to get along very well in doing so; seem to stick on the centers, so to speak, like an old engine that doesn't know whether it's just the proper thing to go ahead or to go back and try it all over again. You've seen just such engines.

It seems to me to be easy enough—that is for one who knows how—to prove anything he wants to prove on the subject; prove it by figures as easily as twice two are four. You can find figures kept in stock, or you can get them made to order, to prove, if you'll only believe, what a lot of humbug there is about clearance; doesn't amount to much if you've only got lots of compression. Compression just covers up the evil, or the most of it. This looks all right; seems all right for your old-fashioned long-ported engine till the other fellow comes along and shows, by better figuring, where the first figures are all wrong. Then comes along the man with the indicator. He joins in the hunt and declares that both are way out; just exactly wrong. Figures may go astray, but the indicator will not lie, and there's what it says. See? Finally some fellow borrows an engine, scales and a coal pile, and proves by avoirdupois that everybody else is wrong, and is never certain that he is anywhere near right. You see, Mr. Editor, it's a good deal easier to prove that everybody else is wrong than to prove that you yourself are right. Comes more natural like.

That's just about where I stand on the compression question at this writing. It's mighty hard finding anything you are willing to nail your faith right to, and you are apt to conclude that the man who doesn't know anything about compression and doesn't pretend to, but goes right along building a pretty good steam engine, is about as good authority as any one. When you try to read up and study up the matter, things that ought to consist don't consist, seems to me. But we all bank on books you know, rely on books and those who ponder over books.

You see it was this way: The old man, Bildmake, had a nice little shop—making money—but was never just satisfied till he started in building a real automatic steam engine. Done the better class of steam engine repairs, the old man had, for all-round, for ten years or more, and two years ago just made up his mind that he could fill a long-felt want by putting a genuine automatic engine on the market himself. Not an "astonisher" or an "eye-opener," or anything of that sort; but something that should turn over right along just as a well conditioned steam engine ought to turn over.

The old man is one of the best men in the world. Wouldn't wrong even himself, not if he knew it, he would'nt. He brought out a half dozen sizes of the new engine, none of them very large; just about right for the trade at Thereaway and the rest of the county; taking care of the local trade, he called it. He had looked after the shop pretty much himself, but now he had to have a draftsman—must have some drawings of the new engine. Then he had to have some one to help him around the shop. There was the general work of the shop to be looked after, which had been growing for some time, and the new engine to be looked after. This is how I have become interested in clearance, compression and the like. You can't build engines without clearance, but you can build them to run without any compression worth grumbling about.

The old man had several engines running, some of them just about as smooth as anybody could ask for, and others that rattled around rather vigorously; seemed to be trying to get away. The old man didn't have time to find out the reason, so he set me to help him, in a sort of a way.

As I remarked, we all bank on books; even the old man when he started in on the new enterprise—automatic steam engines—bought a little library (sort of office library) of books on the steam engine, into which he never looked, not to anyone's knowledge; but when I pressed him on the subject of compression he just referred me right to the library, particularly recommending Rankine. Knew more about engines, Rankine did, in his day, than all the rest put together. Stay as late as you like Saturday afternoon, the old man said, and read up on the whole business. Learn something for yourself and something for the new engine.

I stayed as he advised, and just took down Rankine. Well, now, I could read just about as much of this as I could of Greek, just about; but I could read a plain statement, and I read that the most advantageous adjustment of compression is "when the quantity of steam confined or 'cushioned' is just sufficient to fill the clearance at the initial pressure."

That was plain enough, to be sure, but somehow you always want to see what some one else says. Sort of fortifies your ground; makes you feel safer like, I reckon. Then I found that other authorities quite disagreed with Rankine. Some of them gave formulas that no fellow like me could read, and altogether they left me right in a muddle.

Finally I came to the conclusion that if I were to decide for myself I would arrange to have compression in every one of the old man's engines up to three-quarters boiler pressure, and take the chances.

I wonder if some one or some society will not arrange for experiments that will finally settle the whole business; just let light in for the benefit of us who don't know anything about it, only by the operation of some particular engine we have to do with, and not much then; make it tell its own story that we don't know how to read at present?

George H. Corliss used to build steam engines, and the indicator fellows always said they didn't have compression enough for smooth running or good economy; didn't have any compression at all worth speaking of, perhaps, because there wasn't room in the valve gear for it, and probably because he didn't want it. Didn't talk much about his reasons, they say Mr. Corliss didn't; but he got together an engine that is rather hard to beat. Then other builders followed by jamming whatever was left in the cylinder right up against the boiler, but they never seemed to get away with Mr. Corliss very much.

Speaking about clearance, I know a builder who built an automatic that proved quite too large for the work, just as you have seen a good many engines, I suppose. Well he bushed the cylinder down to about the right size; bushed it way down to where the terminal pressure didn't get all tangled up with the vacuum. Going to save coal, he thought, and everybody else would have thought the same. The cylinder was too large and was bushed to the right size, and the fireman had to wheel just as much coal as he did before.

I suppose the clearance was increased by the bushing—must have been. Wonder just what this had to do with it? Then there was less compression. Sort of at odds and ends, the whole thing seems to be.

JOHN LOOKABACK.

ANVIL AND FIDDLE AGAIN.

OBERLIN SMITH.

I am rather grieved to find that in his interesting article upon British machinery, upon page 159 of the February issue of your paper, my friend Prof. Sweet so sadly misunderstands my views upon "anvil principle" machine-tools as to think that I would be guilty of reducing the width or height of a lathe-bed for the sake of a more compact and solid construction with a given amount of metal. On the contrary, I have always advocated making such structures just as large as there is room for, exactly as would Prof. Sweet, in order to get the stiffness incident to a beam of large lateral dimensions.

The only difference between us is that he would make this beam of box-form so as to get the greatest strength and stiffness with the least amount of material, by the natural process of putting what material there is, out from the neutral line as far as possible, while I would do just the same thing and then fill in the inside of the box with more material so as to make it approximate a solid mass. Mine would, of course, cost more than his; and at the same time would be a great deal stronger and stiffer, although not so strong and stiff as it would be with my same amount of metal put still further out, providing there were room so to put it, which there is not in the case assumed.

It is true that my solid beam would deflect between its end supports by the action of gravity, as much or more as would his hollow box, but this feature is of no practical importance whatever in constructions like lathe-beds, which exist under entirely different conditions from railroad bridges. In considering such pieces of metal we will find, in the first place, that for ordinary lengths of lathes, with beds of proper depth, this deflection does not amount to anything worth considering, even if it was apparent in the way of a departure of the middle portions of the top surface below a true plane. This is because its amount of concavity will be so little, and because the work between the centers would probably also be deflected to as great an amount, that is while not acted upon by the tool. As a matter of fact, however, a shaft or other long piece of work between lathe centers is so lifted by the cutting action of the tool as to be deflected upward far more out of parallel with the bed than would be caused by any gravity deflection downward.

The above assumption of the existence of a concave upper surface we should usually find incorrect, however, because if the man who planed it knew his business, he would have supported the ends of the casting in question at the same points as it would afterwards be supported upon its legs, when setting it upon his planer-table, thus allowing the gravity deflection to exist at that time to the same extent as it was destined to at all subsequent times. He would then dress off the top surfaces as nearly in accordance with true planes as the total depravity of his planer (and other things) would permit.

Though aware that the lathe market is not yet ready for the huge and apparently unnecessary masses of cast-iron which we have been discussing, I firmly believe that any lathe-user who is willing to pay for the same, when placed according to correct principles of design in conjunction with other sufficiently strong, heavy and convenient members of the machine, will find that the additional product attainable will pay as big an interest upon the money invested as any other improved tool about his shop.

As a matter of practical design I do not advocate a mere square log of cast-iron for a lathe-bed, but I do think that if, for a given swing, such a bed was made as wide as there were room for, and as deep as the pocket of the owner could possibly allow, even if it ran clear to the floor, and that if then it was filled in nearly solid, leaving only a generous series of slots down through the centre for the dropping of chips, the two main beams forming the front and back being connected with numerous "cross-girts," very much better results could be obtained in the way of avoiding chatter, and in the taking of heavy cuts, than we now get by the flimsily built, thin, hollow, boxes now in the market. These certainly seem modeled upon the "fiddle-principle," rather than upon that steadfast "anvil-principle," which some few of us have so long and so earnestly advocated.

* * *

DARLING, BROWN & SHARPE, Providence, R. I., announce that, after an extended series of experiments, they have perfected machinery for accurately graduating tempered rules, and have favored us with a fine sample of their work in this line.

THE FIRST PRINCIPLES OF MECHANICS.—5.

THE ELEMENTS OF MACHINES.

LESTER G. FRENCH.

THE LEVER.

Under the subject of moments it was shown that, for a lever to be in equilibrium—that is, for it to balance—the sum of the moments tending to turn it in one direction about its fulcrum, must balance or equal the sum of those which tend to turn it in the opposite direction. This simple principle enables us to solve examples where it is desired to find the length of one of the lever arms, or one of the forces or resistances acting upon the lever, the operation being somewhat similar to that used in finding the reaction of the supports of the beam shown in Fig. 20 of the January number.

A very common, but at the same time a useful, illustration is found in the lever safety-valve.

In Fig. 21, let S be the inside diameter of the valve seat, G the center of gravity of the lever, and W the weight used to hold down the lever and keep the valve closed. The pivot or fulcrum O is the point about which moments are to be taken, and when the valve is just at the point of blowing off, the opposing moments which keep the lever in equilibrium are (1) the pressure against the valve multiplied by the distance A, tending to turn it in a left-hand direction, and (2) the weight W multiplied by C, plus the weight of the lever multiplied by B, tending to turn it in a right hand direction. The weight of the valve itself is comparatively small and may be neglected.

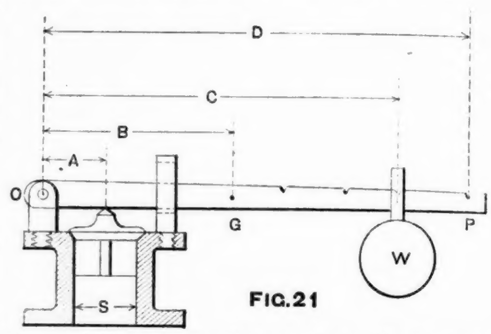


FIG.21

Example:—Let S = 2½ inches, A = 3 inches, B = 15 inches, W=40 pounds, and the weight of the lever 15 pounds.

At what distance from O must W be placed, in order that the valve shall blow off, under a pressure of 100 pounds per square inch?

Total pressure on valve = 2.5^2 x .7854 x 100 = 491 pounds.

Moment of pressure = 491 x 3 = 1473 inch-pounds.

Opposed to this are:

Moment of lever = 15 x 15 = 225 inch-pounds.

Moment of W = 40 x C inch-pounds.

As the opposing moments are equal,

$$40 \times C + 225 = 1473, \text{ or,}$$

$$C = \frac{1473-225}{40} = 31.2 \text{ inches.}$$

This class of problems is perplexing to one who lacks a knowledge of the principles of algebra. A formula in which to substitute the given values may conveniently be used, but even this is likely to be troublesome, unless it is rearranged for each example that arises. We will content ourselves, therefore, with stating in the form of a rule, the different operations that have to be gone through with.

Write the opposing moments in separate groups, using a letter to represent the required quantity.

Select the moment that contains the unknown quantity (40 x C above), and subtract the remaining moments of this group, if any, from those of the other group.

Divide this remainder by the numerical part of the moment previously selected.

Example 2:—In Fig. 21 assume a steam pressure of 25 pounds per square inch, and let D 36 inches, and S, A, B, C, W and weight of the lever be the same as in Example 1. How much upward pressure at point P would be required to cause steam to blow off?

Total steam pressure 2.5^2 x .7854 x 25=122.7 pounds.

Moments tending to cause left-hand rotation are P x 36 and 122.7 x 3=368.1 inch-pounds.

Moments tending to cause right-hand rotation are 15 x 15=225 and 40 x 31.2=1248 inch-pounds.

Select P x 36.

Subtract 368.1 from 225 + 1248; thus, 1473—368.1 1104.9.

The numerical part of the selected moment is 36. Now divide 1104.9 by 36, and the result, 30.7, nearly, is the desired pressure in pounds.

THE PRINCIPLE OF WORK.

There is another principle of more importance than the principle of moments, even in the study of machine elements. It is called the principle of work, and to make it clear, we will analyze the process of the operation of a machine.

1. A force such as the pull of a driving belt, or the pressure of steam, is applied in a given direction at one or more points. The product of the force, and the distance through which it moves, measures the work that is put into the machine.

2. The applied force is transmitted to the point where the operation is to be performed. During the transmission the force is modified in direction and amount, partly by the arrangement of the mechanism and partly by the resisting force of friction, which it must overcome.

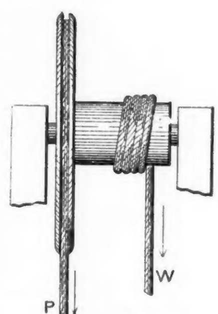


FIG. 22

3. At the point where the operation is performed the modified force overcomes a resistance in any required direction, such, for example, as the resistance of metal to a cutting tool. The product of the resistance, and the distance through which it is overcome, measures the work done *by* the machine.

The principle of work states that, neglecting frictional or other losses, ***the applied force, multiplied by the distance through which it moves, equals the resistance overcome, multiplied by the distance through which it is overcome.*** That is, a force acting through a given distance, can be made to overcome a *greater* force acting as a resistance through a *less* distance; but no possible arrangement can be made to deliver a greater force through the *same* distance.

The principle of work may also be stated as follows:

Work put in=Lost work + Work done by machine.

This principle holds absolutely in every case. It applies equally to a simple lever, the most complex mechanism, or to a so-called "perpetual motion" machine. No machine can be made to perform work unless a somewhat greater amount—enough to make up for the losses—be applied by some external agent.

THE WHEEL AND AXLE.*

This mechanism, Fig, 22, is simply an arrangement for continuing the action of the lever as long as required. So long as a sufficient pull is applied to the rope, which fits into the grooved wheel, to overcome the resistance of the load attached to the rope that passes over the drum, the weight will be raised.

(a). First we will apply the principle of moments. In Fig. 23. let the larger circle represent the circumference of a wheel of radius R, to the periphery of which a force P is applied. Let the smaller circle represent the circumference of the drum of radius r, to the periphery of which is applied a resistance W W.. P and correspond to the pull on the rope and the resistance of the weight indicated in Fig. 22.

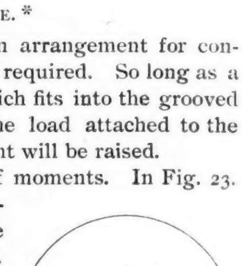


FIG. 23

The moment of the force P about the center O, which corresponds to the fulcrum of a lever, is P multiplied by the perpendicular distance R, it being a principle of geometry that a radius is perpendicular to a line drawn tangent to a circle, at the point of tangency. Also, the opposing moment of W is Wr. Hence, by the principle of moments,

$$P \times R = W \times r.$$

(b). Now, for comparison, we will apply the principle of work. Assuming this principle to be true, the pull P multiplied by the distance passed through by the rope should equal the resistance W multiplied by the distance that the load is raised. In one revolution the driving rope passes through a distance equal to the circumference of the wheel, which is equal to 2 x 3.1416 x R =6.2832 x R, and the hoisting rope passes through a distance equal to 2 x 3.1416 x r 6.2832 x r. Hence, by the principle of work,

$$6.2832 \times P \times R \quad 6.2832 \times W \times r.$$

This statement simply shows that P x R multiplied by 6.2832 equals W x r multiplied by the same number, and it is evident, therefore, that the equality will not be altered by cancelling the 6.2832 and writing:

$$P \times R = W \times r.$$

But this is the same statement that was obtained above by applying the principle of moments. Hence, we see that the principle of moments and the principle of work harmonize.

Example 3.—If the radius of the wheel in Fig. 22 is 20 inches and the radius of the drum 3 inches, how great a pull must be exerted upon the driving rope to raise a weight of 600 pounds?

Substituting in P x R=W x r,

$$P \times 20 = 600 \times 3 = 1800, \text{ and}$$

$$P = \frac{1800}{20} = 90 \text{ pounds.}$$

It is to be observed that in this mechanism the drum may be of any size and that the wheel may be replaced by a crank, since the path described by the crank handle or crank pin is the circumference of a circle of a radius equal to the length of the crank.

WHEEL-WORK.

A series of two or more axles geared together by toothed wheels, or by pulleys connected by belts, is called a *train*. A wheel which imparts motion is called a *driver*, and one which receives the motion a *driven* wheel. It can easily be shown that the basis of operation of a train of wheels is a continuation of the principle of the wheel and axle. In the latter the wheel is in reality a *driven* wheel and the axle or drum a driver, and hence we have that the product of the applied force and the radius of the driven equals the product of the resistance and the radius of

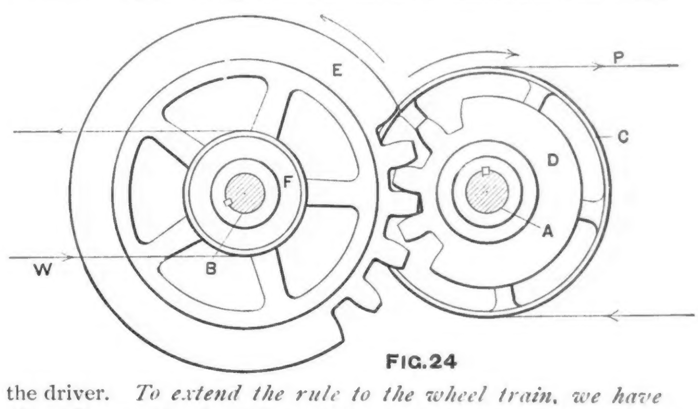


FIG. 24

the driver. *To extend the rule to the wheel train, we have that the continued product of the applied force and the radii of the driven wheels equals the continued product of the resistance and the radii of the drivers.* In calculations, the diameters, or the number of teeth in the wheels may be used instead of the radii, as stated above.

Example 4.—In Fig. 24 two shafts, A and B, are connected by gear-wheels, and also have pulleys for connecting to other shafts by belt. Let the drivers D and F be 20 and 7½ inches in diameter, respectively, and the driven wheels C and E 30 and 40 inches respectively. With a belt pull of 100 pounds on C, what pull would be exerted by the belt running on F, neglecting losses?

$$100 \times 30 \times 40 = W \times 20 \times 7\tfrac{1}{2}, \text{ or}$$

$$120000 = 150 \times W, \text{ and}$$

$$W = \frac{120000}{150} = 800 \text{ pounds.}$$

It will be observed that while the second belt can overcome a resistance of eight times the pull exerted by the first belt, the former moves with only one-eighth the speed of the latter. That is, a gain in force is always accompanied by a compensating loss in speed. If it were desired to calculate the speed transmission, we should have the speed of the first belt, multiplied by the product of the *drivers*, equal to the speed of the last one multiplied by the product of the driven wheels. Thus, if the first belt moves 80 feet per minute, and calling the speed of the second belt S,

$$80 \times 20 \times 7\tfrac{1}{2} = S \times 30 \times 40, \text{ or}$$

S=10, which is one-eighth of 80.

EXERCISE 5.

1 (a). At what steam pressure would the valve shown in Fig,

* The writer is indebted to Jamieson's Elementary Applied Mechanics for a part of the matter under this heading.

21 blow off, assuming that C 25 inches, the other data being the same as before? (b) With a steam pressure of 87 pounds and C=25 inches, what should be the weight of W?

2. If, in addition to the weight W an additional weight of 5 pounds were suspended at P in Fig. 21, what pressure could be carried? Use the data given in Examples 1 and 2 of the text.

3. If a wheel and axle mechanism has a drum 20 inches in diameter and a wheel $6\frac{1}{2}$ feet in diameter, how great a load can be raised by exerting a pull of 125 pounds, neglecting frictional losses?

4. In Fig. 24, let the diameters of the wheels be as follows: Of C 35 inches, D, 6 inches, E, 18 inches and F, 20 inches. If a pull of 1000 pounds be exerted on C, how great a resistance could be overcome by F?

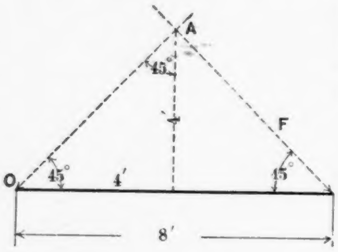


FIG. 25

ANSWERS TO EXERCISE 4.

1. (a) 160 foot-pounds. (b) Fig. 25 illustrates the problem. The moment = F x O A and O A = $\sqrt{4^2 \times 4^2} = 5.66$, nearly. Hence, moment = 20 x 5.66 = 113.2 foot-pounds.

2. No; it will turn in a right-handed direction.

3. This is solved like the examples in the text, and the reactions, of course, will remain the same.

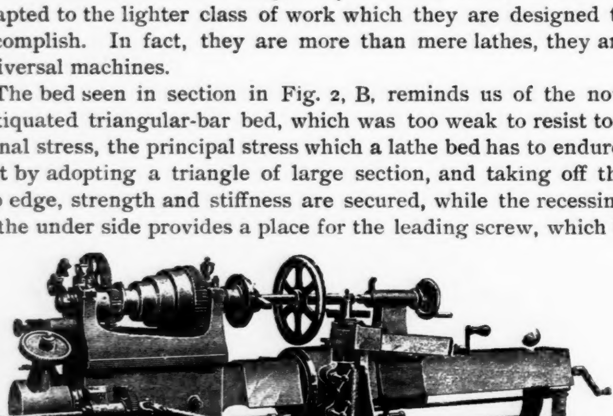
4. The problem is to be solved as before, except that the moment of the force should be obtained by the method used in Example 1 (b).

* * *

THE "PITTLER" LATHE.

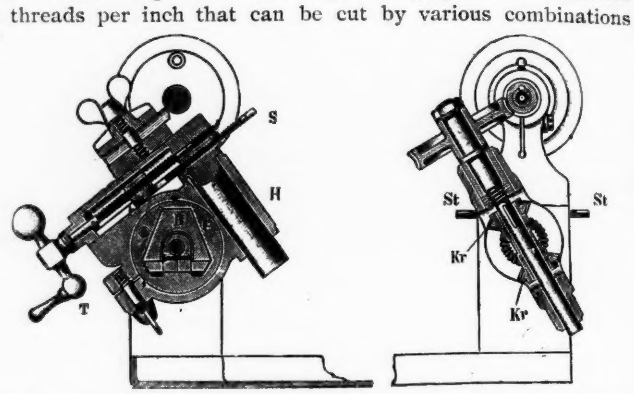
On account of peculiar characteristics, we think the lathes designed by W. von Pittler, of Leipzig-Gohlis, will prove of interest to many of our readers, for although these are not exactly engineers' lathes, yet they embody so many ingenious details of mechanism that they are well worthy of attention, and in many shops they might fill a useful place. In the first place a glance at the general design (Fig. 1) shows that these lathes differ in almost every point of detail from any of the standard kinds with which we are familiar, and nearly everything seems to run counter to our preconceived notions of what a lathe should be; yet, when considered more closely, they are seen to be admirably adapted to the lighter class of work which they are designed to accomplish. In fact, they are more than mere lathes, they are universal machines.

The bed seen in section in Fig. 2, B, reminds us of the now antiquated triangular-bar bed, which was too weak to resist torsional stress, the principal stress which a lathe bed has to endure. But by adopting a triangle of large section, and taking off the top edge, strength and stiffness are secured, while the recessing of the under side provides a place for the leading screw, which is



thus protected absolutely from the abrading action of grit and dust.

These are screw-cutting lathes, but there is no long train of spur change wheels, or swing plate for studs. The screw-cutting is done through a worm located on the tail of the headstock mandrel in the small lathes, as in Fig. 3, or on a second spindle, as in Fig. 1, driving a worm wheel on a swing shaft, the motion being transmitted through bevel wheels to the leading screw. Changes in rate of thread are effected by the substitution of worm wheels having different numbers of teeth, and by different worms. In the larger lathes there are two worms, one being just twice the diameter of the other, either being used as required. The bearing for the bevel wheels is pivoted on the axis of the leading screw, so that it is readily accommodated to whatever worm wheel happens to be in gear. The leading screw is driven forward or backward by one or the other bevels, *Kr*, *Kr*, Fig. 3, either of which is thrown into or out of gear as required with the bevel wheel on the end of the leading screw. The equipment for screw cutting comprises seventeen worm wheels and two worms, one being one-threaded, and one five-threaded. The numbers of teeth on the worm wheels range between twenty and eighty, and the numbers of threads per inch that can be cut by various combinations



range between ten and four hundred. By changing the relative positions of the worms and worm wheels, placing the worm wheels on the mandrel, and worms on the change spindle, together with a dividing plate, spirals of numerous pitches can be cut.

The construction of the slide rest is peculiar. It is not fixed rigidly to the bed, but swivels around it. The saddle C, Fig. 2, which fits the bed and slides longitudinally on it, is circular on the outside A split ring encircles this, and can be clamped in any position. There is a lug H on the split ring with a drilled hole, and in this hole fits and swivels the socket of the top or traversing slide. The leading and most original feature of the lathe lies in this slide rest. It is a universal rest, the universality of its movements being effected in a most simple manner, namely, by the pivoting of the tool in two directions, at right angles with each other, one movement being that of rotation in an axis at right angles with the bed, the other that of rotation in an axis at right angles with the first. There are also, of course, the longitudinal movements of the rest by leading screw, and the feed movement of the tool slide inwards and outwards by hand with the handle T and screw.

The movement round the lathe bed serves as a means of adjustment for the height of the tool point, so that no packing up is necessary. Also, while in ordinary turning the tool slide is horizontal, or approximates to that position, in wheel cutting the tool slide is brought into the perpendicular position for convenience of feeding the blank upwards and downwards in front of the milling tool, which revolves in the lathe axis. Or an angular position can be given to the blank for cutting bevel wheels. By setting the rest at an angle taper turning is readily done. Convex and concave surfaces can be turned truly by swivelling the tool slide around its pivot or post in the socket H. In some of the larger engineers' lathes the circular turning is made automatic. This is illustrated in the first figure. A worm wheel is attached to the bottom end of the pivot, and is driven by a worm actuated by means of a shaft with Hooke's joints, coming from the headstock gear.

Milling can be readily performed in consequence of the universality of movement of the rest. Spur and bevel, worm and helical wheels, milling cutters, tap and reamer grooves can all be readily shaped in these lathes. The cutting or milling tools always run between centers, and the work is carried in the rest, so that there is no need of an overhead movement.

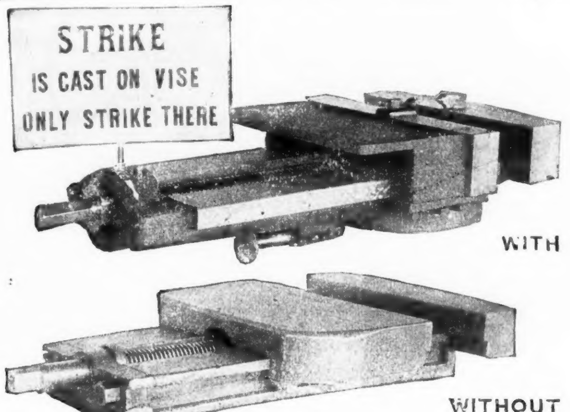
The smallest lathes made are of 3 inch centers, the largest of 12 inch. Lathes from 6 inch to 12 inch centers are made of heavy pattern, and with back gear for the use of engineers especially, in first figure. The lighter lathes are suitable for mechanicians of various classes, being particularly serviceable to those who want a universal tool capable of fulfilling well the functions of the turning and screw-cutting lathe, the milling and wheel-cutting machines.—*The Practical Engineer, London.*

* * *

THE *Scientific Machinist* has improved its appearance and value with the new year, having added H. F. Cook and W. H. Wakeman to its editorial staff, and other well-known writers to its list of contributors.

MACHINE SHOP "KINKS."

Some workmen who are careless (and where is the shop that does not have them) make a practice of striking the vise of a shaper upon the ends to bring it up square, with a hammer or anything else that happens to be handy, thus bruising the sliding surfaces and in a short time practically ruining the vise for efficient work. The evil effects thus produced are very plainly shown in the engraving of an old vise subjected to just such usage, which can be seen in the vise marked "Without." To prevent



this, Gould & Eberhardt have been making the new and original style of vise shown above the old vise, which is furnished with all their shapers of latest design, and which does not lessen their usefulness nor reduce their capacity.

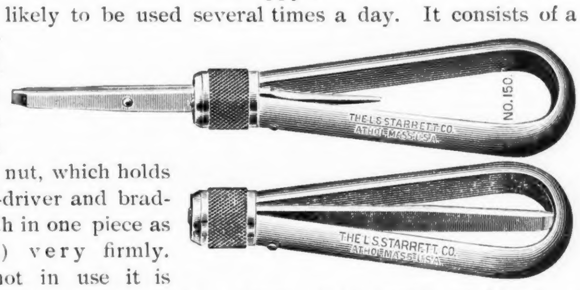
In this vise, provision is made whereby it may be tapped on the end for such fine adjustment as may be required, without in the least injuring the vise in any way. To keep the matter continually before the workman, the makers have cast the word "Strike" on the vise, also arrow-points showing where to strike. It has often been asked by mechanics why the word "Strike" is cast on this vise. The reason is as explained above.

This is a machine shop kink of much practical value and is original with Gould & Eberhardt, and to be found only on shaper vises of their manufacture.

* * *

MACHINISTS' POCKET COMPANION.

This seems to be one of the few instances where a combination tool is really desirable, for there is apparently no objection to offer in this case. Instead there is a happy combination of three tools that are likely to be used several times a day. It consists of a finely finished steel handle with a knurled nut, which holds a screw-driver and bradawl (both in one piece as shown) very firmly. When not in use it is



closed inside the handle. The shape of the handle enables it to be used as an emergency wrench and is often of the greatest convenience and is very light, weighing but two ounces. It is made by the L. S. Starrett Co., Athol, Mass.

* * *

MACHINE-STEEL MILLING CUTTERS.

The item of making and sharpening milling cutters may be made one of the most expensive items about a shop mounting up to the thousands of dollars in a very short time in a shop of any magnitude; and their cost is greatly increased by not only the high price, but the uncertainty of quality of tool steel. The problem in their manufacture and maintenance then is to produce that cutter which shall take off the most pounds of material with the least cost for manufacture of the cutter, for maintaining this last at the requisite degree of sharpness, and at the proper outline and dimensions, and for driving it; for dull cutters or those of poor steel, may prove uneconomical by reason of the power that they take to drive them, and the time of the machine and tender that they consume. In the Newton shops, I find that they are gradually abandoning the use of tool-steel and taking to that of crucible machine steel, case-hardened. Such cutters and reamers are, of course, much cheaper to make than those of tool steel, while their cut is more effective.

* * *

HINTS FOR THE DRAUGHTING ROOM.

W. S. Huyette,

The draughting room is the starting point for the manufacture of any standard or special machinery. Conditions are given for the performance of certain work, and it is the duty of the engineer and draughtsman to decide what mechanism shall be used to produce these results. The size and strength of the various parts, the arrangement in general and in detail must be fixed, and the way the mechanism shall be finished and put together in shop must be carefully considered. The equipment of the shop in the way of machinery and tools should be borne in mind, so that each required operation to the various parts may be done without special tools so far as possible, particularly when only one machine is to be built. This is essential from a financial point of view.

The draughting room should be light and well ventilated, and be kept comfortably warm in the cold weather. The desks or tables should be conveniently arranged for the class of work done in the office. Plenty of room should be provided for passage ways and working space, so as to avoid interference with a man when busy.

Quiet should be maintained so far as possible. Many times during the designing of a machine, consultation or argument between the men, may be necessary or advisable in order to bring out different ideas on the same point. This should be done without loud talking. Many shops have small consultation rooms for this purpose in connection with the draughting room.

A shop engaged on any particular kind of machinery ought to have a library containing all the matter pertaining to that branch that has been published, together with records, tests, etc., of what has been done in the shop. Men do not always remain in the employ of one company, and all die some day; hence, it is to the interest of the company to do away with "walking dictionaries and records." Keep a record of failures as well as successes.

I have known of several cases, where a certain construction has been tried, found objectionable, and discarded. After a lapse of several years, the entire personnel of the office and heads of departments had been changed, and the same construction was carefully considered and used for a similar purpose in a number of machines. In a short time, it was found necessary to change back to what was used on the "old type" machines. The actual losses in this one case would have kept the records complete in every detail from the start, and still leave a balance "to the good."

The draughting room is the place for changes to be made. Make all parts as simple as can be without sacrificing efficiency.

Before the drawings get into the shop, make all changes deemed advisable to meet the above points. It may be tedious and uninteresting, but it will cost less than to let the drawings go out of the office and then find the changes to be necessary after the work is partly finished.

The draughtsman should never forget that a drawing is an accurate, detailed description of whatever it represents, and its purpose is to explain clearly the ideas of the designer to the mechanic and enable him to carry them out to meet the desired requirements. Therefore, all drawings should be made as simple as possible to fully describe the peculiarities of form and finish, and show how each part is fixed in regard to the others. Finely executed lettering and shading does not add anything to the value of a drawing, and does not make a poor design one

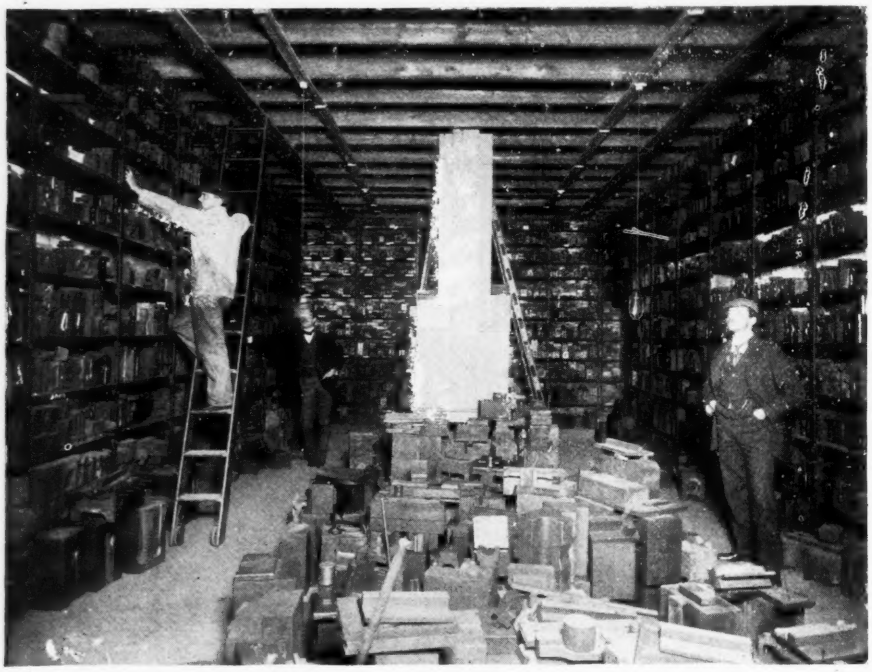
whit better than the bare lines indicate. It also takes time and costs money, and the same time spent in other ways would produce more tangible results.

The size sheet that a drawing shall be made on is fixed largely by the work to be done and the kind of work. When a firm receives drawings from many other companies, to fill in the details of their apparatus, it is impossible to maintain standard sizes of sheets. Where all the work is original in a shop, then standard size sheets should be rigidly adhered to. As the kinds of drawing papers and tracing cloth used come in rolls, the general inclination seems to be towards a 24×36-inch full sheet, 18×24-inch small sheet, 9×12-inch for sketches, tables, etc., and 36×48-inch double size. This enables one to cut standard sheets without waste. The 36-inch tracing cloth, being usually 37 to 38 inches wide, leaves ample space for trimming.

The kind or quality of paper is also decided by the governing conditions. Some shops make the drawings in pencil on a cheap grade of paper, and as soon as completed the drawing is traced on cloth in ink and "blue printed" for shop use, and the original is destroyed. The tracing is kept in the drafting-room for permanent record. Some use a thin linen or bond paper, and ink in the drawing over the pencil lines; blue prints being made in the usual way and the original is preserved. Certain lines of work are handled to good advantage, using cross-section paper and inking in the drawing over the pencil lines and blue printing the necessary copies. While I am much in favor of this method of handling the work, it is not applicable to all kinds of drawings, and when not readily applicable it proves very disadvantageous.

One way I have made use of has proved very satisfactory for work where the design is changed quite often in little details, the main construction remaining the same. The drawings were made on 12×18 inch sheets, one or two details on a sheet, in large scale. I used a buff paper of good quality and inked the drawing in on the paper. The inked drawings were photographed on 8×10 plates and blue prints made from these negatives, mounted on cards and shellaced in the regular way. The result was a small card drawing as clear and distinct as an engraving, readily handled for machine work or bench work. Changes could be made on the original drawing by erasing or pasting patches of new paper, and the drawing finished as before and photographed. The first negative was a permanent record of the original, and each subsequent negative showed the changes from the original. In this way the records were kept full and exact and at little cost. In fact this way would prove a saving in many offices and at the same time maintain true records. The prints were favorably received by the men in the shop in every case, and I never heard any man express a preference for the large scaled drawing. With this method it was impossible to scale the drawings, and the shopmen were obliged to come to the drafting-room for information, and could have no excuse for going wrong.

PRESIDENT'S OFFICE.—BILLINGS & SPENCER CO.



SECTION OF DIE VAULT—BILLINGS & SPENCER CO.

* * *

THE BILLINGS & SPENCER CO.

The accompanying photographs, taken very recently, give an idea of the extent of the business built up by Mr. Charles E Billings, president of the company, who is seen at his desk in the first view. His article, which appeared in our issue of May, 1895, gives an account of the growth of the drop forging industry, which has been largely developed by his energy and skill. The die vault, of which only a section is shown, consists of several rooms in a building as nearly fire-proof as possible, and contains tons of tool steel, whose value mounts up into the hundred thousands of dollars.

The hammer shop is well filled with drop hammers from various makers, the later ones being of their own manufacture and being exceedingly heavy in design. To one who has never witnessed the drop-forging process it is quite a revelation to walk down the long row of hammers and watch the heated metal bars assume shapes that are both intricate and interesting, and it seems almost wonderful that metal can be induced to flow into all the corners and crevices of the dies. Copper commutator bars are also forged here, and this department always presents a busy scene.

The machine room is largely supplied with milling machines, mostly of the Lincoln type, while drills and "edgers" (which are really vertical mills, generally with numerous spindles) abound.

Some of the milling machines here will be illustrated in a later issue.

The repair department is well equipped with tools and crane for heavy work, and the new hammers are also built here. The bases of the largest hammers now weigh 1,800 pounds, which gives an idea of the massive construction used. The building of hammers for the market is quite a new departure for this company, but has been highly successful from the start, and they have all the work in this line they can handle.

* * *

NOTES FROM NOTOWN.—9.

WONDERFUL GRATE BARS—SHOP ADVISER—CONSULTING.

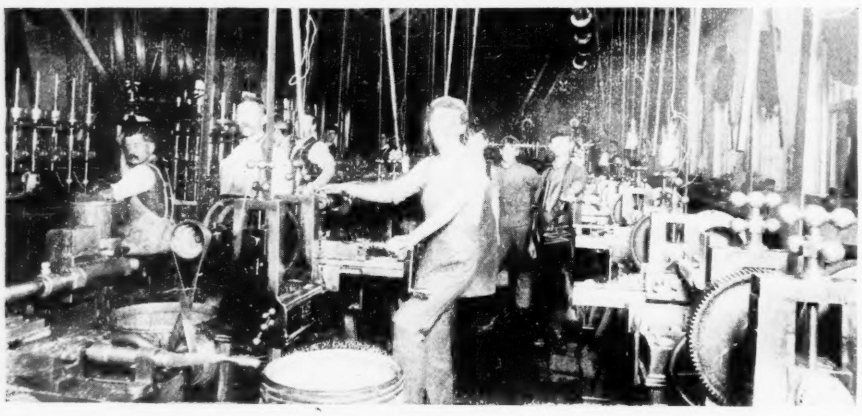
ICHABOD PODUNK

It seems as though I ran across more of the amusing side of shop life than most men, but it may be that I see the funny side where some others pass it by as uninteresting or commonplace. One of the inventive fiends of the town called on Mr. B. the other day, to interest him in a new grate-bar which would do almost everything but sweep the office and shovel snow off the roof. "It has water bars, Mr. B., and as the water circulates through them it prevents burning, so they last a life-time; then you heat your feed-water and save on that, too. Altogether I can guarantee 40 per cent.; I know you would believe that, Mr. B., you're always a doubting Thomas, anyhow; but I can prove it if you'll come down to the Wooden Chair Co. with me—got three in there. And beside that, Mr. B., there's absolutely no scale on the boiler. How does my grate affect the scale? By heating the feed-water and giving a nice even heat to the boiler." "I'm sorry, Bargate; would like to go down with you, but haven't time to-day." "But I'd like to have you, Mr. B.; the Grate Bar Syndicate have been after my patent, and as you are well known in town, I think your recommendation would help me sell it. I've met their committee, explained the new and valuable features and taken them to see the boilers, and we opened one of them to show there was no scale, but they seem to be holding off for some reason. Now if you'll help this along a little I'll make it an object, Mr. B., as I expect to get a good price for it. They asked me one funny question, Mr. B.: they wanted to know why I didn't get the medal of the County Mechanics' Association, last fall, as if the adverse reports of a lot of country yahoots should condemn a mechanical invention of this character." "Well, Bargate, that's rather hard on me," said Mr. B.; "and if you want to know, I'll tell you why you didn't get that medal and why you won't sell this to the syndicate. I am one of the yahoots," and Mr. B. smiled. "To begin with, your water bar wasn't new—used years ago; the circulating device wasn't new—any pump will do that—and besides you didn't circulate a tenth part of the feed-water, so your claim as to heating this isn't worth very much. Your anti-scaling feature is great, if it didn't depend on the use of tri-sodium phosphate or something else, same as any other boiler. No, don't tell me you didn't, because I saw it done when no one thought I was there. Then it's quite likely that the feed-water heater and purifier helped in this line also, and this, added to the fact that the boilers were cleaned every three weeks, makes the efficiency of the grate look rather small. I presume you thought the committee would accept all your statements as facts; but if they did there would be no use of committees; you might just as well write out your own report, select your medal and save time and money. Now, Bargate, don't think every one can be fooled because you have roped in a few. The mechanical public are becoming better posted every day, and engineers are not so afraid of expressing their opinion as formerly. When you get up something that will do half you claim for it, let me know. Good by," and Mr. B. walked away to look after the work on the boring mills.

FORGING DEPARTMENT—BILLINGS & SPENCER CO. PAGE 210.

There's more fun in the shop around the corner, and there's a young fellow there who seems to be creating a kind of a stampede—seems to be minding his own business, too; it's the others that are raising the rumpus. He went into the shop and worked around in the various departments till he got the hang of things; then he disappeared for a few days and no one seemed to know where he was. It wasn't long, however, before he was back; but instead of being on regular work, he was making special tools, jigs, etc., and every one was wondering who he was, and how the "things" were going to work. He was a good natured chap, took all the comments in good part, and was glad of any suggestions. Jigs were made for several parts, and much to the surprise of the old-timers, they worked, and worked well; he had evidently made jigs before. Nor was this all; he gave the fore-

man many pointers, in a quiet unassuming way, which the foreman couldn't get mad at if he wanted to, and he has finally come to rely on him for advice on many subjects, in fact he is what might be called a "shop adviser" in the matter of tools and work, and he has made himself invaluable. The foreman has his hands full with the work of keeping things moving in the shop, and hasn't the time to look after tools and appliances, as this man has. He seems to be a fixture in that shop, anyhow.



PORTION OF MACHINE DEPARTMENT—BILLINGS & SPENCER CO.—PAGE 210.

It seems to me that every one expects a machinist to give all the information he possesses (it may not be very much, and then again it may) for the asking, and to even look up data and work out problems, just for the fun of it, or for the satisfaction of being consulted; but even the idea of being a consulting engineer, *pro tem.*, doesn't buy smoked herring for breakfast, pay the tailor for creasing your overalls, or even renew your subscription to this paper. When I go to a doctor to see if the big toe that arrested the downward career of a lathe cone is in danger of appendicitis or lockjaw, the doctor looks it over, paints it with something that looks like iron-rust and mud, and says "Good morning." Time, ten minutes—I know it means two dollars on my bill at the end of the month.

And then I had to consult a lawyer about my right to shoot Mulgafferty's dog, when he had him chained so his nose came over into my yard, but his three remaining feet were planted on his own premises. The dog wasn't even fit for sausage (home-made), but his business end was on my premises and needed attention. Well it took the lawyer just three minutes to tell me to shoot the dog, and then may be fight Mulgafferty afterwards, etc. This cheerful bit of information cost me five dollars. Now when an aspiring genius comes to me with an alleged new scheme for getting away with the link motion, which, by the way, isn't half so bad as some of its improvers seem to think, he expects me to spend a week in showing why it is of no use except for scrap, and would look on me as a highwayman if I charged even shop time for my services. My advice has probably prevented his investing and losing all his money in the scheme, and yet he would consider a charge of ten dollars as entirely unreasonable.

If all men are of the same mind as those who consult me, it will be some time before you'll see a shingle reading

I. PODUNK
Consulting Engineer.

for I wouldn't get enough to pay for the shingle. Wonder how the other fellows make out?

SHRINKING AND FORCING FITS.

A question which no doubt has puzzled many of your readers, and has been the cause of many inquiries in different mechanical papers, and to which as yet the writer has not seen a very satisfactory answer, is the amount to be allowed for shrinking and forcing fits for different diameters.

In your November number I noticed such an inquiry, and the answer, it seems to me, is far from right. The first part of the answer, "Apply 6 tons per inch of diameter," is about correct; the latter part of the answer, "Allow .004 per inch of diameter," is not correct. We will compare this rule with actual practice which the writer recently had. The pin that we fitted was 12 inches in diameter, and on being asked by the lathe hand the amount that the pin should be left larger than the hole in the crank, the rule was consulted and we found that 12×.004 inches gave .048 inch, which would be entirely too much even for a shrink fit. After comparing some previous experiences, we decided to allow .02, the pin was made that much larger and it took a force of 100 tons to press the pin in the crank; so the writer has decided not to place this rule in his note book.

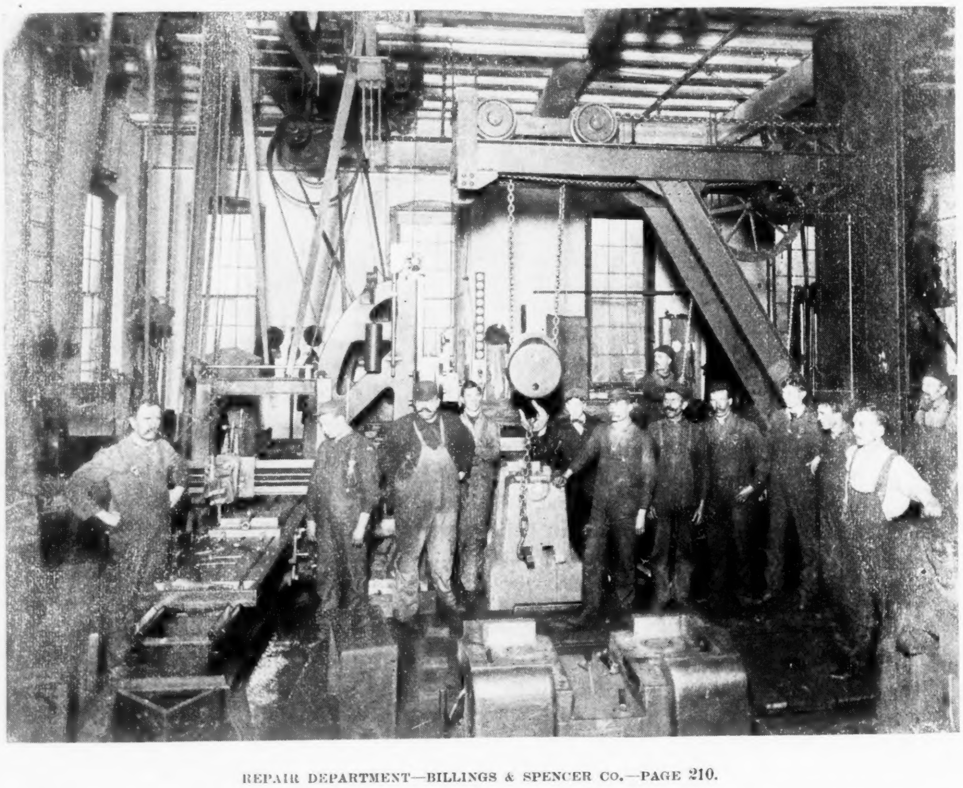
It is the practice in the shop where I am employed, to allow for a 3-inch pin about .008 inch, for a 6-inch pin .012, for a 9-inch pin .016, and we have found by experience that these amounts will give pressure of 25, 45 and 65 tons respectively, which I consider good practice and has given good results.

No hard and fast rule can be given that covers the case; the nature of the metal and the depth of the hole changes the conditions, but the writer believes that if some data from actual practice could be collected and published in your valuable paper, it would prove of great benefit to the average machinist and would do away with a great deal of guesswork which now prevails.

J. H. T.

* * *

It doesn't take long to have the line shaft cleaned up occasionally, and it adds much to the appearance of the shop. But don't have a youngster, or man either, fooling around it with a loose sleeved blouse or shirt, or in such a manner as to risk his being caught, for this can be made a dangerous job and not half try. A good plan is to have the waste fixed in a little box-like arrangement on the end of a long stick, which is filled with waste and moved along the top of the shaft.



REPAIR DEPARTMENT—BILLINGS & SPENCER CO.—PAGE 210.

MACHINE SHOP ARITHMETIC.

A series of practical articles clearly explaining the portions of mathematics which will be useful to the men in the shop and engine room.

PRACTICAL QUESTIONS CONNECTED WITH THIS SUBJECT WILL RECEIVE PROMPT ATTENTION.

ONE RULE FOR ALL.

JOHN H. COOPER.

Every one who has had occasion to figure out the volume or solid contents of any regularly formed geometrical body, has been perplexed in trying to remember the exact rule for each and the way to apply it.

It is a happy state of the memory when every rule can be called to mind exactly, when wanted. A very few mechanics, I imagine, can do this, indeed many can neither learn nor apply them, and many more do not have them at their "finger-ends" at the time when most needed; but whether they can do so or not, *one rule* is more easily remembered than a *dozen*, and I propose to give here *one rule* that will solve all the problems of solidity for regular bodies.

This rule is capable of proof by geometrical methods and demonstration, and may therefore be accepted as true. The simpler methods of proof by equivalents will appear in the comparison of worked-out examples as they are given.

The exact form and method of working out this rule may be given in the following words: All dimensions must be taken in units of a like kind:

Add together { *The area of the base.* / *The area of the top.* / *Four times the area of the middle section.* }

Multiply this sum by one-sixth of the perpendicular height.

The resulting product is the cubic contents, or volume required.

Let us make this clear by worked-out examples: Take a cone 10 inches diameter of base and 12 inches perpendicular height. For this we have:

The area of the base	=	78.54
The area of the top	=	00.00
Four areas of middle section	=	78.54
The sum of these	=	157.08
Multiply by $\frac{1}{6}$ the height	=	2
The volume in cubic inches	=	314.16

NOTE.—The middle section of a cone is a circle half the diameter of the base, which is equal to one-fourth its area, or, to state the same thing, four times the area of a 5-inch circle is equal to the area of a 10-inch circle.

The usual rule for the volume of a cone is: Multiply the area of the base by one-third the perpendicular height, thus:

$$78.54 \times 4 = 314.16.$$

The two rules appear to be the same, as they both show plainly and give correctly a cubic result which is equal to four times the figures representing the area of a 10-inch circle.

Let us now find the solidity of a 10-inch cylinder having 12 inches perpendicular height; here we will have:

The area of the base	=	78.54
The area of the top	=	78.54
Four middle areas	=	314.16
The sum of these	=	471.24
Multiply by $\frac{1}{6}$ the height	=	2
The volume in cubic inches	=	942.48

The usual rule for this solid is: Multiply the area of the base by the perpendicular height, thus:

$$78.54 \times 12 = 942.48.$$

Each process contains and results in figures representing twelve times the area of the base.

Now we know by mathematical demonstration that a cylinder is just three times the volume of a cone of same base diameter and same perpendicular height.

Referring back to the two worked-out examples, it plainly appears that one is three times the other in volume, which presentation gives an all-around proof of the correctness of the rules.

Let us next take a 12-inch cube to find its volume; for this we have:

The area of the base	=	144
The area of the top	=	144
Four middle areas	=	576
The sum of these	=	864
Multiply by $\frac{1}{6}$ the height	=	2
The volume of a 12-inch cube	=	1728

The usual rule is to cube the side, thus: $12 \times 12 \times 12 = 1728$.

Here again both processes contain and result in figures representing twelve times the area of the base.

This rule applies equally to pyramids and prisms of whatever form of base or end. It also applies to frustums of cones, pyramids and prisms.

Whether any of these bodies have their axes perpendicular to their bases or not, this rule applies all the same, care being taken always to use the perpendicular height, never the slant height.

To find the contents of a sphere of say 12 inches diameter, use this rule in the same way as for the cone, thus:

The area of the base	=	00.00
The area of the top	=	00.00
Four middle areas	=	452.39
The sum of these	=	452.39
Multiply by $\frac{1}{6}$ the height	=	2
Volume in cubic inches	=	904.78

The usual rule for this solid is: Multiply the cube of the diameter by .5236, thus: $12 \times 12 \times 12 \times .5236 = 904.78$.

How easily this is done when the workings of the rule are understood. Take the area of a double diameter of the sphere from the tables and multiply it by 2, for the solidity required.

There are some bodies formed like cigars, or that have what is called a spindle shape, which require a little preparation before we apply the rule for obtaining their volume or solid contents? For such we must first consider them as being divided transversely at their largest part, and then calculate each part separately. If both ends are alike, as in the case of a true spindle, then of course after finding the volume of one-half and doubling the result, we will have the volume of the whole; but in the case of a cigar form, one end pointed and the other with the point cut off, we have (when divided as noted above) solids having different lengths and ends and therefore different volumes, and we must calculate each end separately and then add the two together for the volume of the whole.

There is another very important point to which reference must be made when calculating the volume of forms like these which have swelled or convex sides; there must be some means of counting in the swell, or convexity of these solids, and this very feature is included within the measures of the "*one rule for all*;" the element called "four times the area of a middle section" brings in this swell and includes the difference between the volume of a cone of straight sides and having the same base and height, and of the spindle shape having convex sides. We may add right here that this element of the rule covers the cases of cone-like figures bearing concave or hollow sides.

Attention is particularly called to the necessity of taking in the exact measures of these and other similar forms, which every rule would require, if the correct volume be sought for, because this result in every case can only be obtained from all the essential dimensions.

With these explanations clearly stated and before us, we can

proceed to the calculations of the volumes of spindles and frustums of the same, exactly in the same way as already given for cones.

The application of this rule to other forms of bodies will be treated in future articles.

* * *

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

37. F. W. W. asks: What is the best kind of a shop to learn the trade in? *A.* In many ways a repair shop is the best training school one can have, as there is such a variety of work which must be done without special tools, that there is a constant demand for ingenuity on the part of the workman; but as you have evidently had considerable experience in this kind of work, it might be well to go into another shop which would give you an idea of the finer machine work, and at the same time the ideas gained on repair work would be of benefit to you in almost any shop. The difficulty with a large shop is that it is so thoroughly divided into departments, that each man has one specialty, and does nothing else, which, while it is a great factor in economical production, does not give a machinist as varied an experience as is desirable. C.

38. B. R. A., Johnstown, Pa., asks how to calculate change gears for a lathe when it is compounded? *A.* This was treated very clearly by W. L. Cheney, in the issue of February, 1895, and has been added to and made as complete as possible in "Machine Shop Arithmetic," of which he is one of the authors. C.

39. N. J. A. W. asks the following questions: 1. What is the horse power of an engine 5 x 8 inches, plain slide valve, cut-off $\frac{4}{5}$ of stroke, revolutions 240, boiler pressure, 100 pounds. 2. The horse power, with cylinder 5 x 8 inches, double ported balanced slide valve, cut-off $\frac{2}{3}$ stroke, boiler pressure, 125 pounds. 3. The horse power of a tandem compound, cylinders 5 x 8 inches, stroke 8 inches, cut-off $\frac{2}{3}$ stroke. 4. Also give the proportionate water consumption, full capacity.

These are interesting questions, but they cannot be answered with much approximation to exactness. To do that a careful examination of the drawings must be made and everything pertaining to construction taken into account, as well as general arrangement. It it may be possible to get 200 horse power from one engine, and quite impossible to get 100 horse power from another engine with cylinder of equal dimensions. More steam will go through a big hole than through a small one, and so on. If construction is good I should assume that the first named engine could be brought to develop 12 horse power, the second 15, and the third 20, but these figures have no special authority. As to the water consumption, I should assume that it would be about 40 pounds per horse power per hour, and that of the three engines the one named in the second instance would use a little the less. It has been assumed that all the engines are non-condensing. H.

40. E. T., Philadelphia, Pa.: We do not know of any book which will give you instructions on tap and die making. This is a special branch of trade, and as a rule, it does not pay to make regular sized taps in the small quantities usually required in a shop. Special taps and dies can usually be made to advantage. We expect to have an article on this subject in a future issue. The portion of the question regarding space for chips, etc., was answered by question number 32 in the February issue. 2. Give proper angle of twist drills for cast iron, wrought iron, steel and brass? *A.* The usual way of grinding for general work is to have the cutting edges at an angle of 60 degrees with the center line of drill or 120 degrees with each other; this is used for steel as well as wrought and cast iron. For brass, many make the angle 45 degrees with the center line, or 40 degrees with each other, and this is occasionally used for soft cast iron. There is no fixed rule, and the cutting angles are varied in practice, especially where drills are ground by hand. C.

41. Subscriber asks: Will you give me some information concerning a good flooring for the ground floor of a machine shop? The area of the floor is about 22,500 square feet. The machines will be put on independent brick foundations. Information is especially desired about the method of building, cost, etc, of a floor of wooden blocks after immersion in tar. *A.* A good concrete floor is very satisfactory, and can probably be laid for about $2.25 per square yard. We shall be pleased to hear from any of our readers who have had experience with the wooden floors mentioned. C.

* * *

CACULATING STRENGTH OF TEETH—DIAMETRAL SYSTEM.

JOHN L. KLINDWORTH.

Since writing the article, "Strength and Proportions of Gear-wheels," it occurred to me that probably some readers of your paper who have to deal with the diametral pitch system, would like the formulæ (in the October number) for calculating strength, etc., of gear-wheels given in terms of diametral pitch. I shall endeavor to do so in the following.

When we speak, for instance, of 4 diametral pitch, we mean thereby that for every inch of diameter of the wheel there are four teeth on the circumference, or for every ¼ inch of the diameter one tooth on circumference, and as the circumference is 3.1416 times the diameter, if we multiply ¼ inch × 3.416, we have the corresponding circumferential pitch. Putting this in the form of an equation and denoting circumferential pitch by p, diametral pitch number by N, and 3.1416 by π, we may write

$$\frac{1}{N} \times \pi = \frac{\pi}{N} p.$$

For example take diametral pitch number = 4 to find the circumferential pitch which will equal it, we have:

$$p = \frac{\pi}{N} = \frac{3.1416}{4} = .7854 \text{ inch.}$$

If we now substitute this expression $\frac{\pi}{N}$ for p in equation ($4\,b$) of the October number we have:

$$\frac{\pi}{N} = \frac{16.8 \times P}{b \times s} \text{ and } N = \frac{\pi \times b \times s}{16.8 \times P} \quad (6)$$

and equation ($4\,c$) becomes

$$N = \frac{\pi \times s \times n}{16.8 \times A} \quad (6\,a)$$

the load P which one tooth will sustain is:

$$P = \frac{\pi \times b \times s}{16.8 \times N}$$

The width of arm at center will be:

$$W = \sqrt{\frac{\dfrac{T \times b \times 0.9}{a \times \text{thickness}}}{N}}$$

Notations are the same as in the October number.

As an example we will take a wheel of 20 inches diameter to transmit 10 HP. at 80 revolutions per minute. Taking A = 18,000, we get for width of face of wheel:

$$b = \frac{126{,}000 \times \text{HP.}}{A \times D} = \frac{126{,}000 \times 10}{18{,}000 \times 20} = 3\tfrac{1}{8} \text{ inches;}$$

and by ($6\,a$):

$$N = \frac{\pi \times S \times n}{16.8 \times A} = \frac{3.14 \times 3{,}000 \times 80}{16.8 \times 18{,}000} = 2.5 \text{ diam. pitch, nearly.}$$

This gives for wheel of 20 inches diameter, 20 × 2.5 = teeth.

For width of arm at center:

$$W = \frac{\sqrt{\dfrac{50 \times 3.5 \times 0.9}{4 \times \frac{5}{8}}}}{2.5} = 3\tfrac{1}{4} \text{ inches, nearly.}$$

* * *

MAKING JIGS.

It is very often easy to devise jigs and fixtures for work, if the work to be held is uniform, as in cases where they are finished all over. But when dealing with rough castings it is much more difficult, as many a designer knows who has worked on the assumption that all pieces would be like the sample offered.

The writer recalls a case of this kind which will be appreciated by many, where the designer was asked to get out a jig for a certain casting, and after examining quite a number of them carefully, he turned to the foreman with the remark: "We'll either have to find a foundry that can give us more uniform castings, or else make a *rubber* jig." There are cases where this seems to be the only kind that will answer.

ITEMIZED COST OF CASTINGS.

ROBERT GRIMSHAW.

Many a concern goes into bankruptcy because it does not know the exact cost of the things that it sells or the work that it does. Its traveling men and salesmen will make sales, take contracts, accept orders at rates that barely pay cost of materials and labor and which entail considerable extra expense of management and wear and tear of plant; and sometimes it is even worse work is done at less than cost because there is no person whose duty it is to take account of cost, and no system of doing it properly even if there was one person so charged.

A very conspicuous example of the other extreme is the Yale & Towne Mfg Co., which combines in a high degree in its personal make-up both the business and the mechanical senses.

I will take thefoundry department as a good example of how to find out what each item costs, what departments pay best, where leaks occur. and commence with the brass foundry, in connection with which the firm has a sheet 10½×15 inches, which we shall call "No. 1." The left side of this sheet is devoted to ruling having the following column headings:

(1) Metal, Fuel, Labor, Material.
(2) Weight.
(3) Rate.
(4) Account.
(5) Total.

In the first columns appear the items Copper, Tin, Spelter, Lead, Hardening Mixture (the amount opposite these items being added up and carried over to the "Total" column). Back Stock, Bronze Scrap, Brass Scrap, and Turnings, forming a second group, the sum of the amounts in which is also taken to the "Total" column; Coal and Charcoal forming one group of two, Crucibles and All Other Metals another group of two, Labor being the last item, which is entered directly in the "Total" column. These five items give the Gross Cost of Metal Melted; from this is deducted the cost of back stock, leaving the much desired figure of "Net Cost of Metal Melted." From this is deducted the cost of metal per pound, melted, and the cost of metal per pound of product melted.

In the right-hand upper corner of this sheet No. 1 come seven columns:

(1) Account No.
(2) Names of items.
(3) Labor.
(4) Material.
(5) Total (these five making up the foundry expenses).
(6) Account Money.
(7) Amount; these two makup "General Expenses."

Under "Account No," come the shop designations of accounts, as follows: 20 N, General Shop Expenses, including foreman's salary; 67 N, Yard Laborers; 68 N, Freight and Trucking; 69 N, Return Charges for Defective Work; 76 N. Repairs and Renewals of Tools, etc.; 77 N, Repairs to Machinery and Building; 86 N, Additions to Tools, etc.; 93 N, Experiments; thus forming a total under "Foundry Expenses." Under the head of General Expenses come the four items Lighting, Heat, Power, and Water Supply; and one formed by a certain percentage of productive labor which covers all general expenses not specified above.

There is also on the same sheet a "Scrap Account" having these items: Amount of Scrap and Turnings returned to Foundry during the month; ditto Melted into Pigs; ditto Used; then cost of this in three items:

(1) Labor, Cleaning and Melting.
(2) Fuel.
(3) Crucibles and other Materials, these giving a total amount which is the Cost per Pound.

There being a little space at the bottom of the sheet, this is utilized by the Cost of Hardening Mixture; Tin, —— per cent. —— pounds at ———— dollars, and same line for Zinc and for Lead.

Sheet No. 1 evidently earns its cost many times over.

Now turning to Sheet No. 2, which is also for the brass foundry, its headings are as follows:

(1) Division letter.
(2) Class of Work.
(3) Product (pounds).
(4) Cost per Pound.
(5) Cost of Metal.
(6) Cost of Melting: (*a*) labor. (*b*) material.
(7) Cost of Finishing; (*a*) labor, (*b*) material.
(8) Foundry Expenses.
(9) General Expenses.
(10) Total.
(11) Cost per Pound for the Month: (*a*) shop, (*b*) total.
(12) Cost per Pound for six months: (*a*) shop, (*b*) total.

In the first and second columns which items are as follows: A A, Double-faced work of extra quality; A, Double-faced work, regular; B B, Butts, above three inches; B, Butts below three and one-half inches; C, P. O. work, Escutcheons (mortise and rim) and Padlocks; D D, Time and Automatic Lock Work; D, Dial Lock Work; G, Fine Floor Work; H, Collins Co. Work; J J, Machinery Work for Department D; J, Machinery Work for Department C; K, Roller Bushings; L, Aluminum; R, Plain and Ornamental Work; T, Cabinet Lock Work (Department F); W, Oil-cup Covers.

At the foot of this Sheet No. 2 come the following lines: Number on Pay Roll: (*a*) melters, (*b*) helpers; Average Wages of Melters per hour: (*a*) day work, (*b*) piece work; Cost of Labor: (*a*) melting, per pound; (*b*) finishing, per pound; (*c*) foundry expenses, per pound; Cost per pound of Metal: (*a*) melted, (*b*) product; Cost of Scrap per pound; Ratio of Metal Melted per pound of Fuel; Ratio of Product per 100 pounds Melted.

Sheet 2 evidently gives the company a very clear idea of what is going on in every branch of its business, and would enable a leak to be very promptly detected.

There is now Sheet No. 3, which is 11½×36 inches, folded so as to make four pages each 11½×18 inches. On the first page comes the summary. The headings are "Product," and the letters of the departments. Under the head "Product" come the following items: Hardware for Regular Work, A, —— pounds; Differential Blocks, B B, —— pounds; Machinery Castings less than 100 pounds. B, —— pounds; Do. between 100 and 300 pounds, C, —— pounds; Do. between 300 and 1,000 pounds, D, —— pounds; Loam and Dry Sand, with intricate cores, E E, —— pounds; Loam and Dry Sand, plain, E, —— pounds; For Hoisting, etc., G, —— pounds; For Pillars, etc., H, —— pounds; Butts (these seven items ending the list of machinery castings), Butts, Padlocks and Gate Fixtures, J, —— pounds; Rim and Mortise Locks, K, —— pounds; Dial Locks, N, —— pounds; Differential Blocks, P, —— pounds; Total, so many pounds; Total Charges, so many dollars; Average Cost per pound.

Under this come the five items: Average Number of Names on Pay Roll, Total Number of Hours Productive Labor, Average Wages per hour, Weight of Returned Castings, and Charges on Returned Castings.

On the same page there are columns headed with the department letters A A, A, etc., in which there are entered the following: Product, pounds, metal, cents (per pound of product): Cost of Metal, including melting; Molding, Finishing, including delivery; Foundry Expenses, and General Expenses; these giving totals from which are deduced for each department the average cost per pound per month, the average cost per pound for six months, and to which are added the rates charged for castings.

The "Expense Charge" page gives on the one side the Cost of Labor and Materials, and the Total Cost, for the following items: 20 M, General Shop Expenses, including clerks and stationery, cleaning shops and machinery, freights and trucking, and repairs to building and machinery; 67 M, Yard Laborers; 69 M, Return Charges for Defective Work; 76 M, Repairs, Renewals and Alterations of Tools, etc., which simply replace things worn out or destroyed; 86 M, Repairs and Additions of tools, etc., tending to increase permanent values; 93 M, Experiments. These constitute Foundry Expenses. On the right-hand side of the page are General Expenses, giving in the columns of Labor, Materials and Totals, the following: 10 M, Clerks and Stationery; 20 M, General Superintendence of Works; 20 M, Gas and Light; 20 M, Insurance of Works, and Taxes; 20 M, Watching, Fire Apparatus, etc.; K A, Steam; K B, Power; K C, Heat; K E, Water Supply. Then Foundry Charges and General Expenses together make up the Expense Charge page.

The page devoted to Labor, Materials and Expenses contains three divisions: Moulding, Finishing and Foundry Expenses. Each of these has four columns, headed respectively Labor, Materials, Totals and Average per pound; for the various items, Castings Aa, Castings A, Castings Bb, and so on.

On the fourth page of this large sheet come other cost items, as follows: Metal, so many pounds at so much per ton of 2,240 pounds, these lines being left for various lots and prices; Scrap, also rated at a given price. These two furnish the Cost of New Metal, to which is added Back Stock to get "Total Melted." The costs of fire-sand and fire-clay are added together and brought into the Cost of Metal Melted; the costs of Coal, Coke and Wood are added and brought into the same column as Total Cost of Fuel;

and then there is obtained the total Cost of Metal, Sand, Clay and Fuel, which is carried forward. The next items are Labor (tending cupola, weighing, handling metal and fuel, etc., as per account MM, so many hours at so many cents per hour), giving Gross Cost of Metal, Sand, Clay, Fuel and Labor; from which is deducted cost of back stock, giving Net Cost of Metal Melted. From this are deduced "Average Cost per pound, Melted," and "Average Cost per pound of Product." The Ratio of Fuel to Weight of Iron Melted and the Ratio of Product to Metal Melted are given here.

The cost and the average per pound of annealing comes in a separate compartment of this sheet; the items being Labor during the month, Cost of (*a*) fuel, (*b*) sand and clay, (*c*) materials; these giving a total from which is got the Number of Pounds Annealed and the Total Cost of doing it.

In another compartment come the Cost of A castings per pound, to which is added the Cost of Annealing per pound to get the Cost of A castings Annealed. The average cost per pound for the last six months is then given.

It is evident that in this establishment there are not many petty expenses likely to eat a hole, unsuspected, in the profits; and that at any time the place and cost of betterment or of deterioration may be discovered; also that the company can tell to a fraction just how close it may estimate on any given job.

* * *

WHAT MECHANICS THINK.

THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

HINTS FOR YOUNG DRAFTSMEN.

With the idea of helping beginners, I will give a few hints, which are very easy, but at the same time, if overlooked in the beginning, will come harder afterwards:

1. In making sketches to a scale, have all parts scale accurately.
2. In drawing with ink, set pens so as to make the desired line for drawings, and then draw a line across the adjusting screw, parallel with the pen.
3. When it comes to inking in drawings, be careful to hold the pen in one position, for holding the pen in different positions gives an uneven line.
4. Always draw circles and irregular curves first.
5. After the drawing is all finished except dimensions, put the dimension lines in with red ink, make arrow-heads and figures with black ink, and be careful to have them all the same size.
6. When making a drawing, if it is from a sketch or tracing over some old drawing, be sure to understand what every line represents.
7. Study up on valves and their position in regard to the crank.
8. Learn all about the indicator and how to figure indicator diagrams.
9. As most steam engineering of to-day is connected with electricity, read up on power plants. CLAYTON G. BUNNELL.

Elmira, N. Y.

THE INERTIA GOVERNOR.

In the article on "Inertia Governor" in the January issue of your paper, Mr. Begtrup shows by Fig. 5 on page 122, a combination which appears to have been designed by him. A careful measurement of the figure clearly indicates that the centrifugal moment about the weight arm pivot is less when the weight is in the outer position than when in the inner position, while of course the spring moment varies in the opposite direction.

It would be interesting to know whether this is the way the governor is actually constructed or whether the figure referred to is merely a diagram whose measurements are incorrect. It would hardly seem possible to operate a governor in this way.

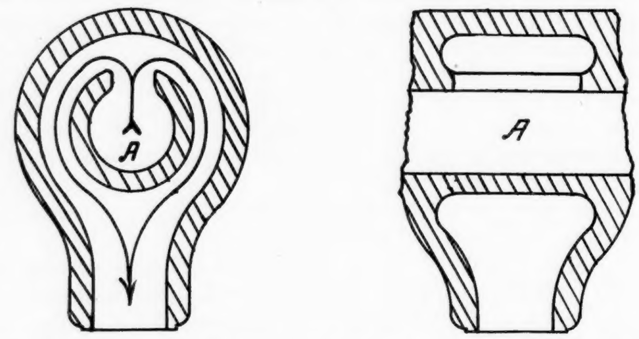
Salem, O. A. K. MANSFIELD.

Mr. Mansfield's query touches an interesting point in the design of my inertia governor, which ought to be explained. In my description I have only this: "The centrifugal weight is bolted to one end of the inertia weight which is cast hollow to receive it." This is of course the end where the spring is, and the above explanation may appear sufficient to a casual reader; but by closer investigation it will be found that, ignoring the extension B, the moment of centrifugal force of the weight C will, by a constant speed, be nearly equal for all positions of the arm, and it may easily be a little less in the outer than in the inner position. The extension B is light and near the center and does not change this condition very much. If this was the only condition isochronous action would be impossible, for the moment of the spring will be greater when it stretches, and if the moment of centrifugal force remains constant, the speed would have to increase very much to obtain equilibrium in the outer position; at any rate a very long spring would be needed for approximate isochronism. But the fact is that by high speed rather short springs are used, and they are very seldom longer than shown in my diagram. This is due to the action of the reciprocating parts, to the centrifugal effect of the valve, rocker and rods. This effect is exactly as if half the weight of the reciprocating parts was hung on the eccentric at B, and the virtual center of centrifugal force will therefore be at the common center of gravity of the weight at C and half the reciprocating parts at B. It will now readily be seen that the resultant moment of centrifugal force may increase considerably when the weight moves out, and that a quite moderate initial extension of the spring will suffice. I think that this effect of the reciprocating parts on governors for single valve engines is often overlooked. J. BEGTRUP.

Ridgway, Pa.

SHOP PROBLEMS.

Here is something in the line suggested by Mr. Usher, for the machinist or pattern-maker to solve, and as it is an actual case the solution must meet practical requirements. The cross-section shows an overflow in a water-pipe casting, and it is desired to



core the piece with only one core-box, as using a separate core is apt to leave a fin where they meet. It was solved satisfactorily at slight cost, and hundreds have been cast from the single core-box. How was it done? CALEB TOPHAM.

Hoboken, N. J.

STATE THINGS PLAINLY.

Times and habits of life change, like other things. It is only a few years since tests connected with the operation of machinery were made for the benefit of the scientific man and those possessed of a high technical education. These men rather readily comprehended letters and signs of signification, and as well as the probable meaning of ambiguous language, because they had been trained to do so. But the majority of readers of such tests to-day are not men who have spent a fair share of their lives in going to college or institute, and to them many signs and allusions generally appearing in such tests are likely to be confusing. There are letters and allusions that are so old and common as to have become known to all, but this is not always the case. They may not know, especially the younger readers, what J or even B. T. U. mean, but they are interested in reading articles in which such letters and others appear, and sometimes are confused by them. Especially are they confused by ambiguous language—language that may be clear enough to the initiated. They take what is said and not what is meant.

It may be reasoned that men should become familiar with signs, abbreviations and allusions before reading such matter, but boys learning trades at three dollars a week cannot generally provide themselves with a technical library for this purpose, and many men are similarly troubled. A vast number of men depend upon the technical press to enlighten them, and they have a right to demand that things be stated so plainly as to leave no room for misconception. If writers for the technical press would keep this in mind it might sometimes save the editor from appending an explanatory note. The writers can explain arbitrary signs in parenthesis, if it seems advisable to use them.

I am led to the foregoing by having seen some very interesting

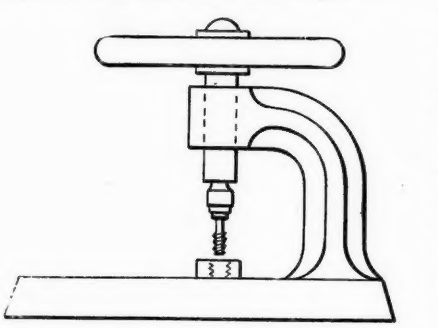
accounts of the tests of roller bearings for shafting, by which, I presume from the reading, is meant line shafting. The remarkable saving in the friction of the shafting of from 40 to 50 per cent. is set down, as indicated by a Prony brake and the indicator (would not a transmitting dynamometer have been better). What mainly appealed to me was this statement, which I use here principally as a text. This was an account of the test of roller bearings, of which the following is as much as is pertinent. It is in reference to a change to roller bearings, presumably on line shaft. This account says the company to which allusion is made "have put in the rollers since this plant was fitted up, and from their indicator cards taken from their steam engine before and after putting in the rollers, they found that their saving is over 40 per cent." Now will not the average reader infer that this means that the saving has been over 40 per cent. on the total power required to drive everything around the works, nothing to the contrary being said? I think that there is danger of his doing so, a danger that should have been guarded against.

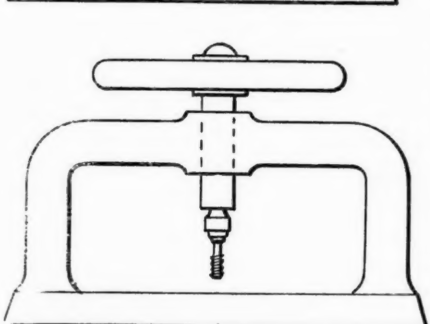
Those who read such accounts should do so with caution and painstaking, to determine what is really meant. And writers should be at more pains to make their meaning clearly apparent.

A GRUMBLER.

A HANDY TAPPING FRAME.

We had a lot of small tapping to do, and as it was considered boys' work it was sometimes a question whether the taps broken wouldn't pay for a man on that job. A copying press that had been discarded by the office was called into play, the threaded hole bored out and a plain spindle fitted in the hole with a device in lower end for holding taps. The handwheel was again used and the rig looked like the lower sketch. This was used successfully for the work in hand, and was so handy that another was made as shown in upper view, the single column being more convenient to use than the other one. This was also fitted with a small size Almond drill chuck and is one of the best rigs for small tapping that I know of. It is used up to ¼ and ⅜ inch taps, and prevents breaking them in most cases as well as insuring the hole at right angles with the base of frame.





R. E. MARKS.

Camden, N. J.

PHENOMENA OF FRICTION.

It is sometimes rather amusing to hear of advanced engineers putting on their thinking caps and commence "dithering" about simple mechanical causes, which are fully understood or made use of. A box or pulley *slides* off or on a shaft, when the shaft is stationary, but *screws* on, when either box or shaft revolves. And that is the whole explanation of this "surprising phenomena." For example: It requires 50 pounds to slide a box along a 2-inch shaft at a rate of 1 inch per second, what will be the weight necessary to move the box at the same speed if the shaft makes 120 revolutions per minute = 2 revolutions per second. Two revolutions per 1 inch lateral movement gives one-half pitch. Then by using a formula similar to those for theoretical screws, we have:

$$P=\frac{R\,p}{D\,\pi}=\frac{50\times\frac{1}{2}}{6.28}=\text{about 4 pounds.}$$

P=power or weight required.
R=resistance of box on stationary shaft.
D=diameter of shaft.
p=pitch.

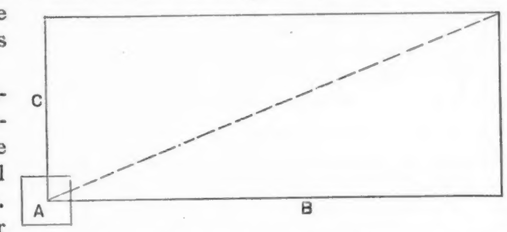
This simple formula of course does not take into consideration friction and slip, which could be determined by experiments similar to those Mr. Cooper refers to.

Of course I may be all wrong, but will stick to this conception, till a better explanation than "dithering" is offered.

Bridgeport, Conn. H. HEYRODT.

PHENOMENAL FRICTION.

Mr. John H. Cooper, in his "Modern Data of the Phenomena of Sliding Surfaces," speaks, in your issue for January, 1896, of the freedom with which shafting may be moved endwise when in rapid rotation, when, on the contrary, the same shaft at rest cannot be made to slide on its bearings.



The explanation is very simple, and the sketch will make it clear. Let us consider piece A moving on a flat surface acted on by force B. It will be sufficient to apply force C perpendicular to make piece A move in the direction of the line C D. Now consider a shaft in rotation; the force B is the force to apply to make it revolve, for force C and this force B takes all the sliding friction of the shaft. This force C will therefore be smaller for the same longitudinal displacement according to the speed of rotation of the shaft.

Hoping that I have made my meaning understood,

Brussells, Belgium. ARTHUR BOLLINCKX.

JOULES'S EQUIVALENT.

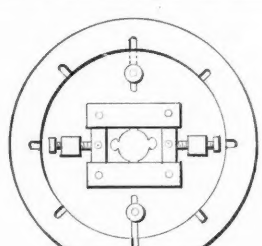
It may interest Mr. Hemenway, in relation to his foot-note in the January number, to know that E. J, Houston, Ph. D., and A. C. Kennelly, Sc. D., in "Electric Heating," page 29, give the B. T. U. as 778 foot-pounds. The authority of these gentlemen is the very highest.

In looking over several authorities the results vary from 772 to 780 foot-pounds. As long as authorities differ, how can anyone expect ordinary everyday mortals to agree.

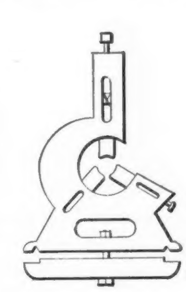
Joule's constant is not 772 for New York latitude and sea level, but about 773.2. IRVING A. TAYLOR.

A PIPE-THREADING DEVICE.

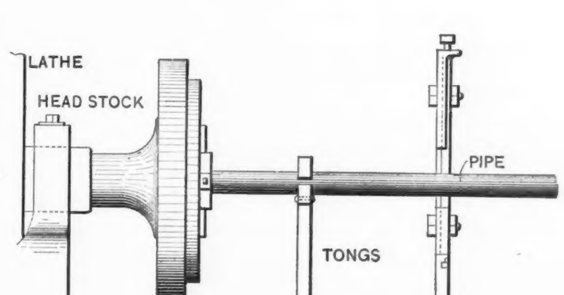
The accompanying sketch shows a handy pipe-threading device which was made by Mr. Edward Waite, of Rockville, Conn., and as it is very useful to us, thought might also be of value to others, We use an old lathe, or at least one that is not new, which is



FACE PLATE AND DIEPLATE



REST.



fitted with a face-plate and die-plate as seen in the sketch. A regular steady rest (of the usual unsteady character) supports the outer ends of the pipe, and the tongs persuade the pipe to remain stationary and not get dizzy, while the die revolves around it.

Rockville, Conn. A. H.

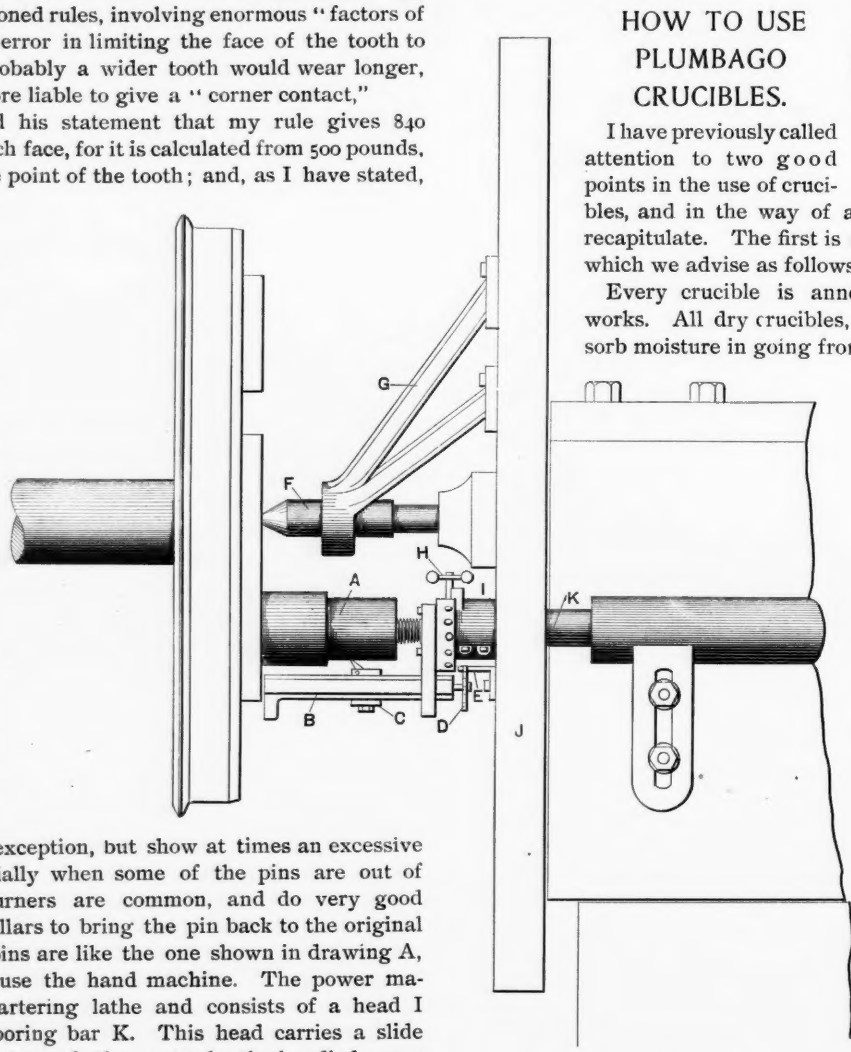
STRENGTH OF GEAR TEETH.

I am much obliged to Mr. Klindworth for his answer to my question as to his data for strength of gear teeth. I have no doubt if we got together we should practically agree, for we are looking at the question from two different standpoints. He, from the sudden strains of a rolling mill; I, from the steady pull of a large cotton or woolen mill, where the power varies very little, from "start-up" to "shut-down." I base my strain on Mr. West's breaking tests of 8,000 pounds per cubic inch, and take one-sixteenth of that, or 500 pounds, as the safe strain at pitch line, to cover all allowances for "point of tooth," or "corner" contact. This is irrespective of speed, the higher the speed the more power can be transmitted, and what I did not understand was the connection between 1,570 feet per minute and 1,500 pounds strain. He now says that slow moving gears with a steady load, he would allow up to 5,000 pounds strain. I still fail to understand the *basis* from which he makes his calculations. I do not place much reliance on any of the European formulæ on any of these matters, as our American iron is notoriously stronger than theirs, and even the best of these writers still cling tenaciously to old-fashioned rules, involving enormous "factors of safety." I may be in error in limiting the face of the tooth to 2½ times the pitch, probably a wider tooth would wear longer, but it would also be more liable to give a "corner contact,"

I do not understand his statement that my rule gives 840 pounds pressure per inch face, for it is calculated from 500 pounds, unless he takes it at the point of the tooth; and, as I have stated, I do not expect the strain to be ever-thrown on the point of one tooth only, but that a second tooth should always engage before the first one "let go," and when it got down to such small pinions as to make this difficult, I would "shroud" the teeth.

SAMUEL WEBBER.
Charlestown, N. H.

A CRANK-PIN TURNER.



A CRANK-PIN TURNER.

As is well known in stationary practice, a crank-pin does not wear round, but on the contrary nine-tenths of the wear is on one side. A locomotive's pins are no exception, but show at times an excessive amount of wear, especially when some of the pins are out of quarter. Hand pin turners are common, and do very good work when there are collars to bring the pin back to the original centers, but when the pins are like the one shown in drawing A, it is not practicable to use the hand machine. The power machine is used in a quartering lathe and consists of a head I clamped to the end of boring bar K. This head carries a slide which is moved from or towards the center by the handled screw H. To the slide is bolted the slotted bar B, and in this bar is the tool-block C, which is fed right or left by a screw carrying on its end the star wheel D.

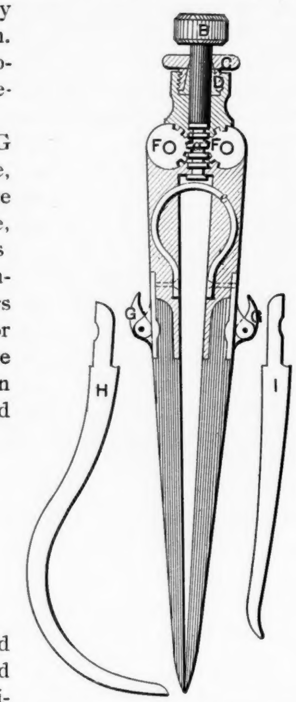
In operation, the driving-wheels are placed on the centers as shown, the long center being supported by the bracket G and crank-pin brought to position, then wheels are clamped in place. The tool revolves around pin, the star feed striking tappet E at each revolution. Feed can be changed in either direction by changing position of E. The work is done quickly and easily with the advantage of bringing the pins exactly in quarter.

Corning, N. Y. FRED E. ROGERS.

* * *

NOVEL CALIPERS.

The calipers shown have never been illustrated to my knowledge, and as I think they are useful, send them to give others the benefit. The legs are provided with teeth around the joints as at F F, which mesh in screw *a*, operated by thumb-piece B. After the adjustment is obtained they are locked in position by clamping the bushing D around the rod by means of the clamp-nut C, as shown. Any tendency to "shake," or lost motion is overcome by bow-spring *e* between legs, just below the joints.



By means of springs and pawls G the leg points are interchangeable, and the divider points shown in place can be replaced by any desired style, like those shown, or different ones making it an easy matter to have inside, outside, keyhole or other calipers at short notice, with only one base or body. Of course several pairs are desirable, and can be readily kept on hand. Have other kinks to send later.

RICHARD WATSON.
Detroit, Mich.

* * *

HOW TO USE PLUMBAGO CRUCIBLES.

I have previously called attention to two good points in the use of crucibles, and in the way of a preface will here briefly recapitulate. The first is a proper annealing, about which we advise as follows:

Every crucible is annealed before leaving our works. All dry crucibles, however, are liable to absorb moisture in going from our shop to yours.

On arrival at your works they should be immediately unpacked and stored in a warm, dry place to dry out any moisture possibly absorbed in transit, and to keep them from taking up further dampness.

Then to provide against possible accident it is wise to re-anneal.

Before being placed in a hot furnace the temperature of a crucible should in every instance, in the re-annealing, be slowly raised to at least 212 degrees Fahrenheit, or even a little above the temperature of boiling water. This will remove all moisture.

Remember, in hasty work you take the risk.

Any time a press of work compels you to use our crucibles immediately on arrival, and without the re-annealing up to 212 degrees Fahrenheit, if they scalp or flake off on the first heat, the fault is not in the crucible. We cannot be held accountable for such accidents if our instructions are not observed.

An additional word is, if the crucible be a large one, after toasting its outside walls, set it over a black slow fire bottom side up, that the inside walls as well as the outside can feel the good of the toasting process.

The remaining point before noticed is that the melter shall keep in stock new crucibles—those not before in the fire at all, and also partly used ones—those that have gone sundry heats and have received the vitreous glaze which comes after several heats. Then for his new and slow fires put in the brand-new crucibles, and heat them up gradually, but for the hottest fires always put a crucible in that is coated with the glaze.

The careful observance of these two hints will obviate most of

the cracks and scalps which otherwise might take place on the first or second heat. A crucible having now got safely thus far, its future good behavior depends—

1st. On the fit of the tongs. In a fire hot enough to melt brass, or copper, the crucible becomes soft and pliable. In lifting it out to pour, if the tongs do not fit, or are not made to grip the crucible at the right place, it is easily squeezed out of shape and liable to crack. The Dixon Company suggests that the tongs be made to grip the crucible just below the bilge, so it will not need such a tight squeeze. Some melters use tongs shaped like the Ace of Spades; such tongs remove the coal much more easily than those of the regulation shape.

2d. On the kind of coal used for fuel. Coal with too much sulphur destroys, unnecessarily, the life of the melting-pot. I have seen a car-load of crucibles give 25 per cent. more heats by a change of coal.

3d. The melter must not expect as many heats in melting one metal as another. From three heats when melting nickel, to six in melting steel, to twenty-four in melting copper, the heats run up in the forties when melting composition.

4th. The drafts and dampers, if arranged to produce a reducing atmosphere, as against an oxidizing atmosphere, will lengthen the life of the melting-pot. An oxidizing flame is always unfriendly to a plumbago crucible.

5th. The flux used also bears on the same result. The binding materials in the walls of the crucible are impervious to some fluxes and easy victims to others.

6th. The time of heat is also to be allowed for. If with modern furnaces, high drafts, and taller stacks, the heat is taken off in 1½ to 1¾ hours, don't expect your crucible to stand this large punishment as easy as the lighter strain of a 2½ to a 4 hours' heat.

7th. If in ordering your crucibles you could give a hint to the maker as to what metal is to be melted, he could tell better what crucibles to send.

In the old days a crucible was a crucible; in these modern days we make by twenty different formulas, or mixtures as they are called. So tell your maker what you propose to melt, and you will get a crucible better adapted to the work and one that will last longer.

8th. After pouring your metal, don't roll the pot out of doors where it will get rained upon, or on a bed of wet sand, or where it will absorb moisture. If you do, you put it exactly where in its hot, soft condition it will become spoiled either teetotally or partially. Also in lifting large pots by the crane, don't release the the grip and let them drop four or five feet on stone floor; rather hold the grip until within two or three inches from the ground, and then drop them if possible on a bed of old dry sand.

9th. Don't leave any metal to cool in the crucible, but pour until the melting-pot is clean empty. In the parlance of the shop, don't leave the crucible so you will find a "button" in the bottom when it is cooled off.

In cooling, each button will have small threads or spikes of metal which will attach themselves to the soft crucible walls and get solidly stuck in them, and they tear the walls of the pot to get them out,

10th. In charging the crucible, don't wedge the scrap in too tightly; expansion and contraction go on in the heating and cooling; and a careful charging will provide for this.—John A. Walker, *Vice-President Jos. Dixon Crucible Co.*

* * *

Quite a change has taken place in the J. Stevens Arms and Tool Co.; both Joshua Stevens and James F. Taylor retiring, being succeeded by I. H. Page and Charles P. Fay, both well-known to the trade, having been connected with the L. S. Starrett Co., as well as other manufacturers in this line of work.

The many friends of Christian H. Baush, the head of the well-known firm of C. H. Baush & Sons, Holyoke, Mass., learned of his death on January 7th, after a short illness. He had succeeded in establishing a line of work which is recognized as being of standard quality and excellent design, and the resulting business shows the wisdom of the course pursued.

We regret to announce the death of Daniel Kinnear Clark, on the 22d of January, in his 74th year. He was well known as the author of several standard works on engineering, among which his "Railway Machinery" and "Manual of Rules, Tables and Data for Mechanical Engineers" are probably the best known.

MACHINERY'S REGISTER.

Any Superintendent, Foreman, Machinist, Engineer, Draftsmon, Pattern Maker, Moulder—any person connected with the machinery trades who is seeking a position, can have his name and address and a statement of his qualifications placed on file in our Register for the convenience of those seeking such service as he has to offer, by sending us the necessary information and ten cents in stamps, which is intended to cover only the actual cost to us. Sample statements are given below:

FOREMAN.

A thorough mechanic, 31 years old, 13 years' experience, has had charge of department in Blankford Machine Co., wishes a change with a different class of work. Can handle men to advan age and secure rapid work without antagonizing the men. Best references.

Address, Frank Jones, 25 Blank St., Blankford, Conn.

VISE HAND.

A machinist with ten years' experience at high grade engine vise work, would like a similar position with a view to eventually taking charge of the department.

Address, George Brown, 46 Dash Ave., Dashville, Ohio.

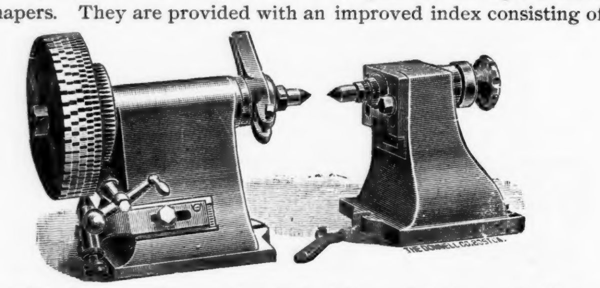
These statements *are not published;* but copied by a typewriter on uniform sized sheets of paper and filed in our Register, typewritten copies being sent to employers needing such assistance. Each application is continued in the register until the desired position is secured, provided the time does not exceed six months.

To employers who are seeking employees in the above trades we will send copies of five statements with names and addresses, for four cents in stamps. If we have no applications on file that answer the inquiry we will advertise for them at our own expense.

* * *

IMPROVED 13-INCH CENTERS.

We illustrate herewith a pair of centers, made by the Davis & Egan Machine Tool Co. (formerly the Lodge & Davis Machine Tool Co.), of Cincinnati, O., which are designed for use on planers, milling machines and shapers. They are provided with an improved index consisting of



five circular plates or discs, each 5/16 inch thick and 7¼ inches in diameter, which are accurately cut with 44, 52, 56, 90 and 96 notches respectively, giving a wide range of divisions. These plates are readily taken off and others substituted, with different numbers for special work. These plates being cut through like a gear, give a much stronger pin than a drilled index. This index is revolved by means of a worm and gear, which are readily disconnected (by loosening one bolt) when not required. Tongues are inserted in bottom of head and tail stocks, and are readily taken out and fitted to the machine, without destroying the alignment.

The spindles, worm and screw are made of the best steel.—*Adv.*

* * *

MANUFACTURING NOTES.

LIDGERWOOD CABLEWAYS FOR THE PANAMA CANAL.

Spencer Miller, M. E., engineer of the department of hoisting and conveying machinery of the Lidgerwood Manufacturing Co., New York City, who recently went abroad in the interests of that company, has just closed a contract with the Compagnie Nouvelle Du Canal De Panama at Paris, for seven Lidgerwood cable ways, to be used on the Panama Canal. This company is one that has been recently formed to complete the great Panama Canal, and the seven cableways will be used exclusively for earth excavating. They will be equipped with all the latest improvement, including the patent aerial dump, which is such an important feature of these machines, the apparatus throughout being similar in construction to the twenty Lidgerwood cableways used on the Chicago Main Drainage Canal, except that the Panama cableways will have fixed towers and anchorages. The spans will range from 250 to 300 feet. This is one of the largest single orders for cableways of any description ever received by any concern in this country from abroad, and points to a world-wide appreciation of the merits of the Lidgerwood Cableway that fully justifies the claims advanced by manufacturers that it is the most perfect, economical and efficient apparatus of its kind ever devised.

Messrs. W. A. Crook & Bros. Co., Newark, N. J., the prominent builders of high-grade hoisting machinery, have just established a branch office at Boston, Mass., corner of Franklin and Pearl streets, to

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E. P. Roberts, M. E., President. Send for Catalogue. J. C. [illegible], Secretary.

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This book is *entirely different from any other* on machine-shop practice. It is not descriptive of universal or common shop usage, but shows **Special ways of doing work, better, more cheaply and more Rapidly than usual,** as done in fifty or more leading shops in Europe and America. Some of its *over 500 Items and 222 Illustrations*, are contributed directly for its pages by eminent constructors; the rest have been gathered by the author in his *Thirty Years' Travel and Experience*. It is the *most useful book yet issued for the Machinist*. No shop can afford to be without it. Every employee can fit himself for advancement by studying its pages. It will *benefit all from apprentice to proprietor.*

Read what the editor of this paper, "Machinery," says of it:

This is an interestingly written book, with fair sized type and plenty of good engravings, which are a great help in making clear any text, no matter how well written. There are over five hundred separate items, selected from the author's observations and the observations of others, as well as from the leading mechanical papers, MACHINERY being well represented. It abounds in handy ways of doing work, commonly called shop kinks, as the title of the book implies, and there is enough useful information in the book to repay the outlay many times over. The devices shown are all taken from actual practice and the name of the shops where they are to be found is given, so there is nothing that can be called untried or impractical in it. The information imparted by books of this class, especially when written by men of long experience, is the most valuable that can be obtained, and the intelligent shopmen will carefully consider the means employed in various shops, determine which is best adapted to his particular case, and adopt the method that will save the most time and money for their employer. We believe it will pay any shop to have a small library of practical books of this kind, to be consulted by the foreman and others who are interested. No machinist can read it without finding new methods and ideas which will be of value to him.

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The book fully justifies itself, and there are thousands of shops in which it should be studied.—*American Machinist.*

There is nothing experimental or visionary about this book, all devices being in actual use and giving good results. It might perhaps be called a compendium of shop methods, showing a variety of special tools and appliances which will give new ideas to many mechanics, from the superintendent to the man at the bench. It will be found a valuable addition to any machinist's library, and will be consulted whenever a new or difficult job is to be done, whether it is boring, milling, turning or planing, as they are treated in a practical manner.—*Machinery.*

*** Special illustrated circular of either of the above sent on application. Both of the above books sent, prepaid, on receipt of $5, or either one on receipt of $2.50. Our catalogue of books for Machinists, Mechanics, Electricians and all practical trades sent free on request.

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accommodate the increased business from that section. In addition to their large line of hoisting engines for building, pile-driving and general contractors' use, W. A. Crook & Bros. Co. build improved hoists for mining and other hoisting purposes, which operate by electricity and which have become extremely popular.

DIXON'S SILICA GRAPHITE PAINT, manufactured by the Joseph Dixon Crucible Co., of Jersey City, N. J., will be used in painting all the tin work and skylights of the Post Office Department Building at Washington. A quantity will also be used on the Capitol, and the District Government Building.

MR. J. S. MUNDY, of Newark, N. J., the hoisting engine builder, has a contract from the New York Central & Hudson River R. R. for building their new draw-bridge engine for the Spuyten Duyvil Creek draw. This draw-bridge has a span of 290 feet. The engine has double cylinders with reverse link motion, and operates two lines of steel shafts 4¾ inches in diameter, by gearing, for opening and closing the draw. The engine is specially arranged for operating their temporary lift draw that is now in use across the Spuyten Duyvil Creek, and as soon as the permanent draw-bridge is erected will be transferred to the new draw.

ELEGANT new Wagner equipment on all limited trains of the New York Central—fast time and absolute comfort.

THE MOSSBERG MFG. CO., Attleboro, Mass., announce that they have purchased the entire line of power punching and embossing presses formerly manufactured by the Horton Mfg. Co., of Reading. Mass. This enables them to offer one of the largest lines of power presses manufactured.

THE ELECTRIC EMERY WHEEL CO., formerly of Hartford, Conn., have moved to 874 Broad street, Newark, N. J., where they have in creased facilities for handling a large business promptly. They give an absolute guarantee of their wheels, which should insure their good quality.

THE export trade of the Davis & Egan Machine Tool Co. (formerly the Lodge & Davis Machine Tool Co.) has increased materially in the last year and is still increasing. They are now making shipments nearly every week to England. They have just completed a large order and shipped same to Mexico, and will in a few days ship one of their large machines to one of the biggest machine shops in Vienna. They have just received an inquiry from a large concern in Buenos Ayres, South America, for a number of their large tools.

THE ASHTON VALVE COMPANY are running full time on railroad and mill work, which speaks well for the Ashton goods, as this is due to a recognition of their high quality and not to low price. This result is especially gratifying on account of the action of some concerns in cutting prices below the prevailing rates.

P. R. JACKSON & CO. LTD., Salford Rolling Mills, Manchester, England, sent us section A of their general catalogue which contains many halftones, illustrating their works and products, which are varied and interesting. This firm makes very large gear wheels, one pair of helical wheels being shown which weighs 28 tons. There are many thing of interest to the mechanic, some of which we may mention later.

MORNING, noon and night the fast trains of the New York Central leave Grand Central Station, center of the city, for Chicago, Cincinnati, St. Louis and the West.

* * *

FRESH FROM THE PRESS.

THE NORWALK IRON WORKS CO., South Norwalk, Conn., send us their new catalog of The "Norwalk" Air and Gas Compressor, which is very complete in description and details, and also contains a large amount of information which is extremely useful to those who are interested in this line of work. Compressed air has become such a factor in modern shop work, as well as for many other purposes, that progressive mechanics must keep posted to be abreast of the times.

THE KNOWLES STEAM PUMP WORKS, 93 Liberty street, New York, have issued a special catalog on electrically operated power pumps which shows a variety of pumps of several sizes and for various purposes, driven by the ever ready and convenient electric motor, which is fast becoming a permanent feature in pump construction. The catalog also contains information on pumps and their capacities.

"HOME STUDY" is the name of a new monthly publication by the Colliery Engineer Co., Scranton, Pa., which should be in demand among the students of their correspondence schools, as well as others who desire to advance in their chosen occupations. Its twenty-four pages are full of information on steam engineering, architecture, plumbing, heating and ventilation, geometry, drawing, mining, popular science, civil engineering, electricity and mechanics, while correspondents' questions are clearly answered. It is edited by F. W. Ewald, M. E., with J. J. Clarke, M. E., associate, Chas. J. Hayes, illustrator. Price, $1.50 per year.

THE BETTS MACHINE CO., Wilmington, Del., favor us with a '96 catalog of their planing machines. It is finely illustrated with half-tones, and gives briefly and in concise language the main features of their planers for various purposes. They are of neat and substantial design and are regularly made in eleven sizes, ranging from 36 to 120 inches, with tables of various widths to suit different requirements. Their Frog and Switch Planer is an extremely powerful machine, built for exceptionally heavy duty. Those interested will want a copy for reference.

THE DIGEST OF PHYSICAL TESTS AND LABORATORY PRACTICE. Published by Frederick Riehle, 1,424 North 9th street, Philadelphia, Pa. The first issue of this quarterly has appeared and does credit to both publisher and editor, who by the way is H. M. Norris one of our contributors, assisted by L. R. Shellenberger. It is standard size (6x9 inches) and contains eighty-six reading pages, which are of great interest to the engineer and mechanic who deal in any way with the strength and property of materials. It is a resume of practical tests made in the laboratories of the world. The frontispiece is a portrait of Mr. John Fritz, president of the A. S. M. E., and there is a very interesting sketch of his life by J. F. Holloway (both from *Cassiers*.) Any engineer will find many times the subscription price ($1.00) in a single issue, and they are sure to be preserved for future reference.

THE SCIENTIFIC MACHINIST CO., Cleveland, O., send us a catalog describing their Institute for Home Study of Engineering. It shows the need of such home study in the various branches of mechanics, steam and electrical engineering and their method of supplying the need. It also describes the apparatus used with these courses, which aid greatly in obtaining a clear idea of the actual performance of machines or instruments. The prices range from $30.00 to $66.00. Those interested should send for a catalog.

THE STANDARD BOILER CO., Marquette Building, Chicago, Ill., have issued a new catalog showing the construction of their water-tube boilers and their advantages. They are built for them by the Link Belt Machinery Co., which speaks well for their construction. As 4,000 HP. of them are being erected for the North Chicago Street Railway, they seem to be making friends at home. We suppose the catalog will be sent on application.

THE EGAN CO., of Cincinnati, O., have issued a poster which they consider the most complete publication of its kind ever printed. They are so sure of this that they invite comments and criticisms from any source.

MACHINE SHOP ARITHMETIC. By Fred H. Colvin and Walter Lee Cheney, Editors of MACHINERY. The Practical Publishing Co., East Orange, N. J. Price 50 cents. With the natural modesty of newspaper men, we quote a review of the book from *Locomotive Engineering*, in preference to any attempt of our own:

"To a mechanic wishing to learn the problems of everyday shop experience, this little book will be the best pocket companion we have ever examined. It has been prepared by two mechanics, who make no pretensions to a range of mathematics soaring above the heads of plain lathe or bench hands. There is nothing in the book that a man who has learned arithmetic will have difficulty in understanding, and every problem and rule in it ought to be understood by every mechanic with ambition to become anything higher than a common workman. The first subjects taken up are decimals, square root, cube root and mensuration. The rules of these divisions of arithmetic are plainly stated, and examples given of their application to shop practice. The formulas employed to indicate methods of calculation are very simply explained. If mechanics would study this department a little, they would not be so readily scared by an article that contains a few formulas to indicate abbreviated calculations. We regret not having the space to give a more detailed review of the book. Among the principal chapters are: Rules for Screw-Cutting, Drilling for Taps, Depth of Thread, Bolts and Nuts, Speed of Pulleys and Gears, Speed of Milling Cutters, Speed of Drills and Taps, Speed of Grindstones and Emery Wheels, Principles of Screw-Cutting."

SHOP KINKS AND MACHINE SHOP CHAT. Robert Grimshaw. Norman W. Henley & Co., New York. 392 pages. $2.50. This is an interestingly written book, with fair sized type and plenty of good engravings, which are a great help in making clear any text, no matter how well written. There are over five hundred separate items, selected from the author's observations and the observations of others, as well as from the leading mechanical papers, MACHINERY being well represented. It abounds in handy ways of doing work, commonly called shop kinks, as the title of the book implies, and there is enough useful information in the book to repay the outlay many times over. The devices shown are all taken from actual practice and the name of the shops where they are to be found is given, so there is nothing that can be called untried or impractical in it. The information imparted by books of this class, especially when written by men of long experience, is the most valuable that can be obtained, and the intelligent shopman will carefully consider the means employed in various shops, determine which is best adapted to his particular case, and adopt the method that will save the most time and money for their employer. We believe it will pay any shop to have a small library of practical books of this kind to be consulted by the foreman and others who are interested. No machinist can read it without finding new methods and ideas which will be of value to him.

Two trains that specially suit Buffalo people are the Empire State Express and the Buffalo Special of the New York Central.

J. B. JOHNSON, Gouverneur, N. Y., sends us a neat little calender with a cut and brief description of his Giant Safety Collar and its advantages in a prominent position. This should bring it before many who are still using the old solid collar with its dangerous projecting set-screw, and will doubtless prove an efficient object lesson.